# The City of Winnipeg

## Water & Waste Department

# Identification Standard

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Revision: 04

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|---|---|---|
| Original Approved By: | C. Wiebe for G. Patton | Dec. 4, 2019 |
| | Geoff Patton, Manager of Engineering | Date |

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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 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.

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.

## 1.3 Document Revisions

Wastewater Planning and Project Delivery Branch (WWPPD) will issue revisions to the document on an as required basis. WWPPD will send out an email requesting review and comments by the division list below.

All proposed revisions shall be circulated to the following divisions and branches:

- Water Services Division
- Wastewater Services Division
- Solid Waste Services Division
- Engineering Division
  - Asset Management Branch
  - Design and Construction Branch
  - Drafting and Graphic Services Branch
  - Land Drainage and Flood Protection Branch
  - Wastewater Planning and Project Delivery Branch
  - Water Planning and Project Delivery Branch

After comments are incorporated into the finalized draft, WWPPD will send a copy of the approved PDF to the Business Communications Coordinator for upload to the Water and Waste Department Website.

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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.

## 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 Area Code

The Area Code (also historically identified as Process Area Codes) identifies the physical area or building in which the equipment is located. A single letter character from A to Z represents a physical area. Some specific recommendations regarding implementation and designation of area codes are:

- For new construction, ensure that areas codes are allocated for a large enough area, such that the 26 available area codes are not exhausted.
- The Area Code 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 area code, not a B (Boilers) area code. 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 locations with different area codes. In this case, the equipment Area Code 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 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 Figure 6-4.
- 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 area at all wastewater treatment plants, but would represent something different for water facilities.

The Area Codes for existing facilities are listed in Appendix B.

## 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 *Area Code*. Equipment numbers may be re-used within different *Area Codes*.

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.

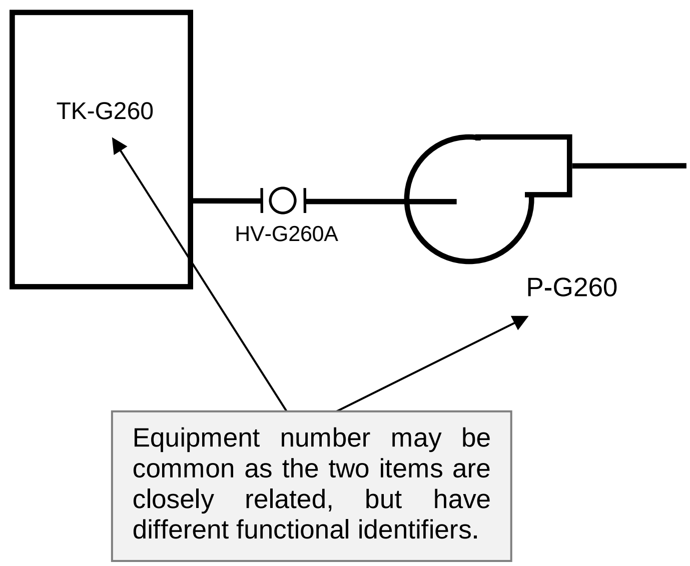



**Figure 2-1: Equipment Number Example – Functionally Related**

Notes:

1. *Electrical and mechanical equipment, that are 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. *As per Sections 6 and 7, all related electrical and automation, including instrumentation, equipment identification will be based upon the associated Equipment Number. When proposing a common Equipment Number for multiple equipment items, consider the impact on the Electrical and Automation disciplines to ensure that the proposed numbering is effective for all disciplines.*

### 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. In addition, the NEWPCC Facility is very large and requires the use of four digit equipment numbers and five digit instrument loop numbers.

**Table 2-1 : Identifier Length**

| Facility | Estimated Equipment Identifiers | Equipment Number of Digits | Instrument Loop Number of Digits | Example Equipment Number |
|---|---|---|---|---|
| Small | < 50 | 2 | 3 | P-M01 |
| Medium to Large | 50 – 3000 | 3 | 4 | P-M101 |
| NEWPCC | > 3000 | 4 | 5 | P-M1101 |

### 2.5.3 Equipment Number Ranges

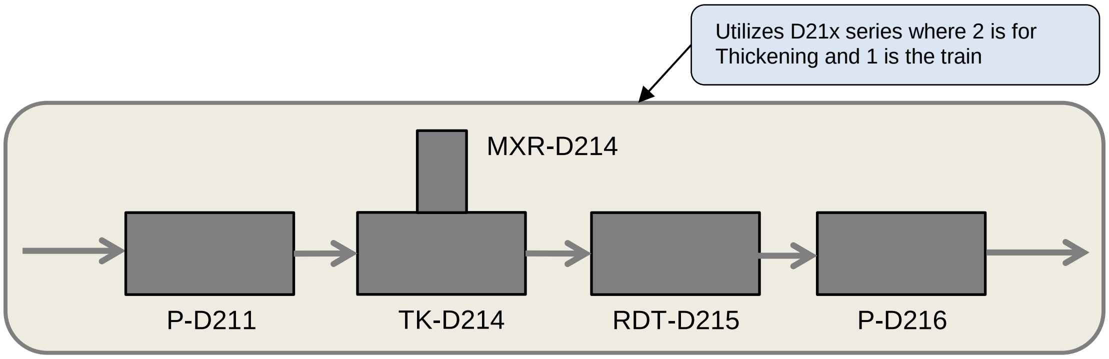
For each facility, the equipment numbers are grouped and allocated in ranges to specific process functions. The range allocations are on a site by site basis, although efforts should be made to utilize common ranges for similar types of facilities.

Equipment number ranges are defined in Appendix D.

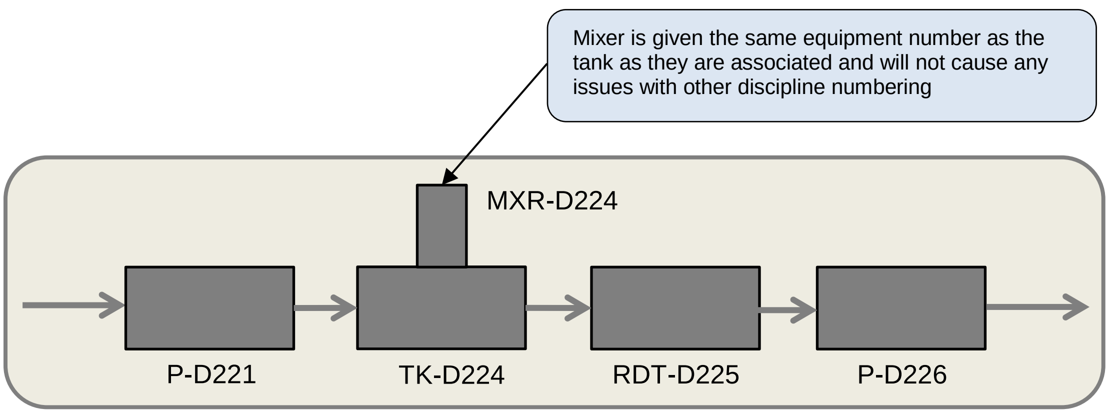
Note that for wastewater treatment plants, the WSTP Project Document Numbering Standard (IMS Document PG-RC-PC-05) identifies a Process Code. The Process Code is analogous to the Equipment Number Ranges, and both are indicated in Appendix D for wastewater treatment plants.

### 2.5.4 Sequential Logical Numbering

Provide equipment numbering with regards to logical sequencing of the equipment numbers as per process flow. Gaps in sequential numbering are acceptable and appropriate provided that they do not excessively waste equipment number ranges. Group process or equipment trains such they utilize a common range. See the examples in Figure 2-2.




Rotary Drum Thickener Train 1




Rotary Drum Thickener Train 2

**Figure 2-2 : Sequential Logical Numbering Example**

### 2.5.5 Coordination with Equipment Descriptions

As far as practical, ensure that the last digit(s) of equipment numbers matches the equipment descriptions.

Examples:

| | |
|---|---|
| P-G201 | The identifier for “Grit Pump 1” |
| P-G202 | The identifier for “Grit Pump 2” |

### 2.5.6 Additional Requirements for Wastewater Treatment Facilities

#### 2.5.6.1 Coordination of Equipment with Electrical Power Supply

The majority of electrical distribution within wastewater treatment facilities is typically configured in a redundant manner. Where redundant electrical distribution is provided, identify the electrical distribution such that the distribution normally fed from Bank 1 ends in an odd number and the distribution normally fed from Bank 2 ends in an even number.

For equipment, as far as practical, provide:

- An odd equipment number for equipment fed from an odd numbered electrical distribution equipment.
- An even equipment number for equipment fed from an even numbered electrical distribution equipment.

Examples:

| | |
|---|---|
| P-G201 | Fed from MCC-G701, which is connected ultimately to Bank 1. |
| P-G204 | Fed from MCC-G702, which is connected ultimately to Bank 2. |

## 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 2-3 and Figure 2-4.

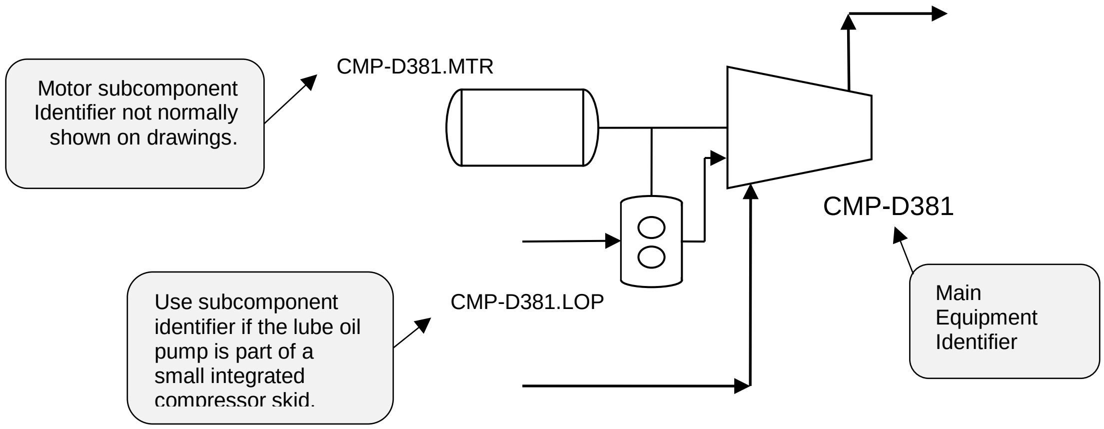



**Figure 2-3 : Lube-Oil Pump Subcomponent Example**

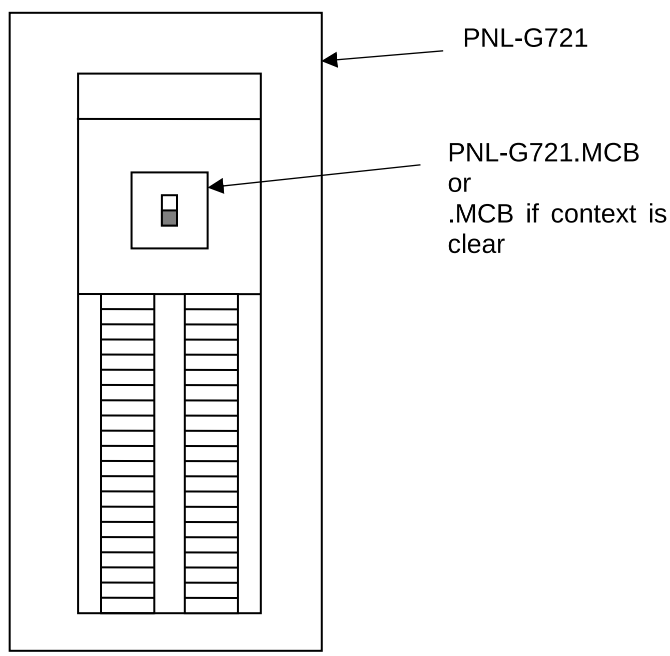



**Figure 2-4 : Electrical Subcomponent Example – Main Circuit Breaker**

# 3 ARCHITECTURAL

## 3.1 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** | **-** | **A** | **-** | **L** | **RR** | **S** |
|---|---|---|---|---|---|---|---|---|
| Facility Code (Optional) | - | Room Designation | - | Area Code | - | 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.

A — is the *Area Code*, which is based on Section 2.3.

L — is the *Level*, which shall typically be one or two characters, as described in Section 3.1.1.

RR — is the *Room Number*, which shall typically be two digits, except as described in Section 3.1.1.

S — is the *Suffix*, which can be utilized to indicate room divisions as required. This should only be utilized for cases such as rooms that are divided by a movable barrier.

Examples:

RM-S-115 — Room 15 in the Secondary Clarifier area, on the main level.

RM-M-222 — Room 22 in the Main Building area, on the second level.

RM-G-BA9 — Room 9 in the Grit area, lower level 2.

*Note: A hyphen is utilized between the Area Code and level, to ensure that room numbers are not potentially confused with equipment numbers.*

### 3.1.1 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<br>(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.*

### 3.1.2 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.

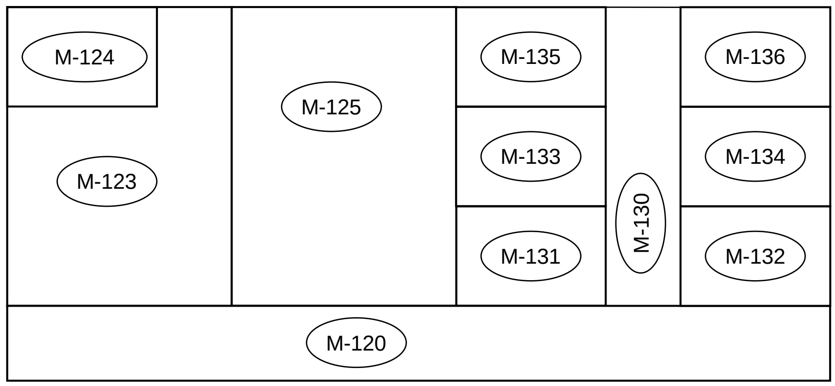



**Figure 3-1 : Room Numbering on Drawings – Plan View**

### 3.1.3 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.
- 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.
- Room numbers shall be assigned in a cohesive fashion between existing, new and modified facilities. Duplicate room numbers are not permitted under any circumstance.
- 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.

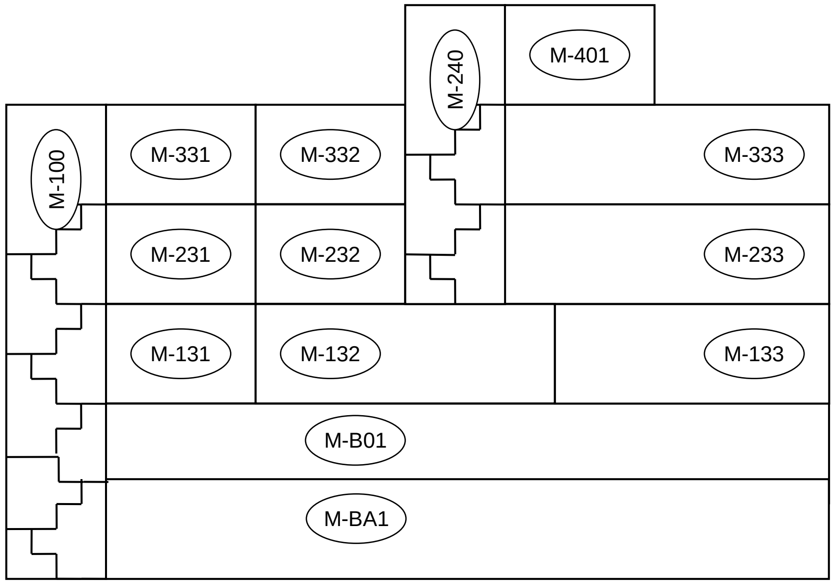



**Figure 3-2 : Stairwell Identification Examples – Elevation View**

- 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.

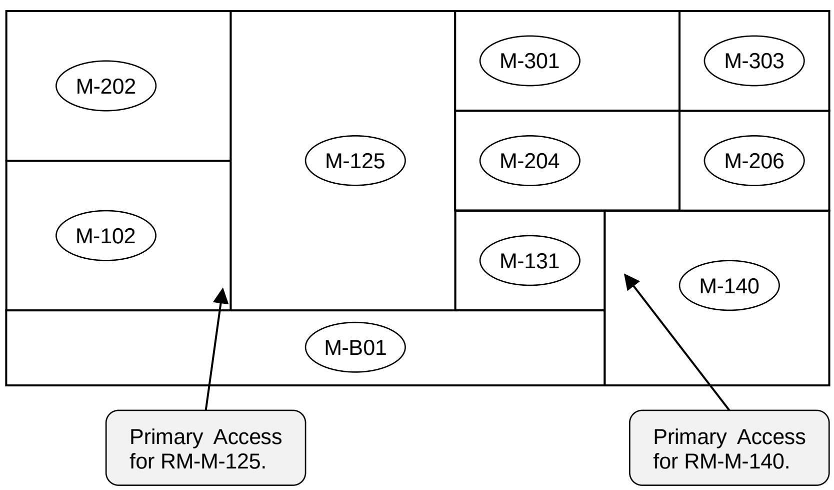



**Figure 3-3 : Multi-Level Room Examples – Elevation View**

## 3.2 Door Identification

It is required to identify door identifiers for architectural purposes and to allow for identification of specific equipment that is associated with rooms. Security system component identification, as discussed in Sections 6.8, are associated with door identifiers. Doors will be identified as follows:

| **FFFF** | **-** | **D** | **-** | **A** | **-** | **L** | **RR** | **S** |
|---|---|---|---|---|---|---|---|---|
| Facility Code (Optional) | - | Door Designation | - | Area Code | - | Level | Room 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.

D — is the *Door Designation*, which is comprised of the letter D.

A — is the *Area Code*, which is based on Section 2.3.

L — is the *Level*, which shall typically be one or two characters, as described in Section 3.1.1.

RR — is the *Room Number*, which shall typically be two digits, except as described in Section 3.1.1.

S — is the *Suffix*, which is utilized to indicate the specific door. Double doors are to be identified with a single identifier.

Examples:

D-S-115A — Door A for Room 15 in the Secondary Clarifier area, on the main level.

D-M-222C — Door C for Room 22 in the Main Building area, on the second level.

D-G-BA9A — Door A for Room 9 in the Grit area, lower level 2.

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# 4 MECHANICAL / PROCESS EQUIPMENT

## 4.1 Identifier Format

Mechanical / process equipment will be identified as follows:

| FFFF | - | EEEE | - | A | NN(N)(N) | - | XX |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Facility Code (Optional) | - | Equipment Functional Designation | - | Area Code | Equipment Number | - | Component Number (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 1 to 4 characters from Section 4.1.14.2.

A — is the *Area Code*, which is based on Section 2.3.

NN(N)(N) — is the *Equipment Number* of the associated equipment. This will be three digits for medium to larger facilities, two digits for smaller facilities, such as Collections facilities, and four digits for very large facilities (NEWPCC).

XX — is the optional Component Number, which can be one or two digits, and shall be applied as per Section 4.1.1.

Examples:

CMP-G201 — A compressor in the G area.

P-M645 — A glycol pump in the M area.

R-R102 — An oxygen reactor in the R 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.

UH-K631-2 — The second unit heater that is controlled by the same thermostat or PLC output as unit heater K-631-1 (the unit heaters will always be on simultaneously)

### 4.1.1 Component Numbers

Component Numbers are suffixes to equipment numbers that are utilized to designate multiple components of a single system. Component numbers will increment starting at 1. Use of a component number is only acceptable if:

- The equipment with the same *Equipment Number* is functionally associated, and
- The equipment has no associated process control or the process control is common or the equipment is part of a common skid package.

Component Numbers shall not be utilized in the following scenarios:

- To address a shortage of available equipment numbers in a given series;
- Where the equipment is not functionally associated; or
- Where the equipment can be manually or automatically controlled to run independently.

*Note: Use of the Component Number should not be common.*

Examples of acceptable uses of Component Numbers:

If AHU-G634 is an air handler, and there is more than one fan in the air handler, it is acceptable to utilize component numbers to designate the individual fans.

## 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 5.2.5. |
| BDD | Backdraft Damper | See Section 5.2.5. |
| BFP | Back Flow Preventer | |
| BLR | Boiler | |
| ~~BS~~ | ~~Bar Screen~~ | Use SCR |
| BV | Balancing Valve | Manual mechanical balancing valve (not typically adjusted by operations). See Section 5.2.3 |
| BVA | Automatic Balancing Valve | Automatic mechanical balancing valve. See Section 5.2.3 |
| CAL | Calibration Column | |
| CC | Cooling Coil | |
| CDR | Condenser | |
| CE | Centrifuge | |
| CHLR | Chiller | |
| CM | Clarifier Mechanism | |
| CMP | Compressor | |
| CNV | Conveyor | Includes skimmers |

| Functional Designation | Description | Notes |
|---|---|---|
| CRN | Crane | |
| CT | Cooling Tower | |
| CU | Condensing Unit | |
| CV | Check Valve | See Section 5.2 |
| CYC | Cyclone | |
| EDU | Eductor | |
| EF | Exhaust Fan | |
| F | Fan - General | |
| FA | Flame Arrestor | |
| FC | Fan Coil | |
| FD | Fire Damper | See Section 5.2.5.<br>Utilize same equipment number as air handler / fan. |
| FDR | Feeder | Examples screw feeder, chlorinator, glycol make-up unit |
| FEX | Fire Extinguisher | |
| FG | Flap Gate | |
| FIL | Filter | |
| GR | Grille / Louvre – General | See Section 4.3. |
| GRD | Grille – Diffuser | |
| 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 | |
| PCV | Pressure Control Valve (Pressure Regulator) | See Section 5.2.3 |
| PSV | Pressure Safety/Relief Valve | See Section 5.2.3 |
| R | Reactor (various processes) | |

| Functional Designation | Description | Notes |
|---|---|---|
| RDT | Rotary Drum Thickener | |
| RES | Reservoir | Large water containment structure. |
| S | Skid Package | |
| SA | Sampler | |
| SCBR | Scrubber | |
| SCR | Screen | Utilized for screening systems such as bar screens and perforated plate screens. |
| SD | Smoke Damper | See Section 5.2.5.<br>Utilize same equipment number as air handler / fan. |
| SF | Supply Fan | |
| SL | Stop Logs | See Section 5.2.3 |
| SLG | Sluice Gate | May only be utilized within existing facilities where the use of the SLG identifier is well established. The designation may not to be utilized for new or upgraded WSTP facilities. Identify as a valve (HV, XV, FV, etc). |
| 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 | |
| WCP | Washer / Compactor | Typical for wastewater screenings |
| WGB | Waste Gas Burner | |

*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 Grilles

HVAC grilles, louvres and diffusers, will be identified as follows:

| FFFF | - | EEEE | - | A | NN(N)(N) | - | XX |
|---|---|---|---|---|---|---|---|
| Facility Code (Optional) | - | Equipment Functional Designation | - | Area Code | 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 Section4.2.

A is the *Area Code*, which is based on Section 2.3.

NN(N)(N) 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:

GRD-M645-1 The first diffuser grille associated with SF-M645.

GR-P682-1 Intake louvre associated with SF-P682.

GR-P682-22 The 22$^{nd}$ 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 | |
| CC | Cooling Coil | May be a subcomponent of a AHU |
| HC | Heating Coil | May be a subcomponent of a AHU |
| HRC | Heat Recovery Coil | May be a subcomponent of a AHU |
| 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 AND DUCT

## 5.1 Pipe and Duct Designation

The identification format for piping and ductwork is as follows.

| P | - | CCC | - | MMNN | - | SNN | - | LLLL |
|---|---|---|---|---|---|---|---|---|
| Pipe Nominal Size | - | Fluid Commodity Code | - | Pipe Specification Code (Optional) | - | Insulation Specification Code (Optional) | - | Line Number (Optional) |

Where,

P — is the nominal pipe size in 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 from Table 5-3, and NN is a number referencing the specific specification. Note that MM must be letters. See Notes 1 and 2.

SNN — is the optional *Pipe Specification Code*, where S is the insulation material / type from Table 5-4, and NN is a number indicating the thickness of the insulation in mm. Note that S must be a letter.

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:*

1. *It is recommended that a common set of pipe specifications be developed for each type of facility.*
2. *For existing facilities, where the exact pipe specification is not known, the Pipe Specification Code may be omitted.*
3. *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.*
4. *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 |
|---|---|---|---|---|---|---|---|
| **6** | 1/8 | **80** | 3 | **275** | 11 | **750** | 30 |
| **8** | ¼ | **90** | 3 ½ | **300** | 12 | **800** | 32 |
| **10** | 3/8 | **100** | 4 | **350** | 14 | **850** | 34 |
| **15** | ½ | **112** | 4 ½ | **400** | 16 | **900** | 36 |
| **20** | ¾ | **125** | 5 | **450** | 18 | **950** | 38 |
| **25** | 1 | **150** | 6 | **500** | 20 | **1000** | 40 |
| **32** | 1 ¼ | **175** | 7 | **550** | 22 | **1100** | 44 |
| **40** | 1 ½ | **200** | 8 | **600** | 24 | **1200** | 48 |
| **50** | 2 | **225** | 9 | **650** | 26 | **1300** | 52 |
| **65** | 2 ½ | **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 | Air, High Pressure |
| ALP | Air, Low Pressure | Air, Low Pressure |
| AS | Air Scour | |
| BLS | | Ballasted Sludge |
| BS | Brine Solution | |
| BSD | | Biosolids, Dewatered |
| BSL | | Biosolids, Liquid |
| 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 |
| CEF | | Centrate - Final |
| CEI | | Centrate - Intermediate |
| 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 (including Digester Gas 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 | Obsolete (was Drain non-process)<br>Use SAN or LDS |
| DCW | Domestic Cold Water | (use PW) |
| DD | Deacon Effluent (Post UV) | |
| DDW | Demineralized Water | |

| Code | Commodity - Water | Commodity - Wastewater |
|---|---|---|
| DEA | Dilute Acid | |
| DEC | Dilute Caustic | |
| DF | DAF Float | |
| DG | | Digester Gas |
| DGC | | Digester Gas - Conditioned |
| DGH | | Digester Gas, High Pressure |
| DFR | Diesel Fuel Return | Diesel Fuel Return |
| DFS | Diesel Fuel Supply | Diesel Fuel Supply |
| 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) | |
| EA | | Exhaust Air |
| EE | Engine Exhaust | |
| ES | Electric Supply | Electric Supply |
| EXP | Expansion Tank Equalizer Line | |
| FC | Ferric Chloride | Ferric Chloride |
| FE | | Final Effluent |
| FED | Filter Media Eduction | |
| FIN | Filter Influent | |
| FIR | Firewater | |
| FLT | | Filtrate |
| FOA | | Foul Air |
| FOR | Fuel Oil Return | |
| FOS | Fuel Oil Supply | |
| FOV | Fuel Oil Vent | |
| FPG | Fire Protection Glycol Solution | Fire Protection Glycol Solution |
| FPW | Fire Protection Water | Fire Protection Water |
| FSF | | Fermented Sludge Filtrate |
| FSL | | Fermenter Sludge |
| FSU | | Fermenter Supernatant |
| FSW | | Flushing Water |

| Code | Commodity - Water | Commodity - Wastewater |
|---|---|---|
| | | (Plant Effluent Water) |
| FTR | Filter To Recycle | |
| FW | Filtered Water | |
| GE | | Grit Effluent |
| GOX | Gaseous Oxygen | |
| GR | Glycol Return | Glycol Return |
| GRS | | Grit Slurry |
| GRT | | Grit (Solids / Dewatered) |
| 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 | |
| HRE | | High-Rate clarifier Effluent |
| HRS | | High-Rate clarifier Sludge |
| 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 |
| MA | | Mixed Air |
| MC | | Magnesium Chloride |
| MET | | Methanol |
| ML | | Mixed Liquor |
| MP | | Mixed Polymer |
| MPC | Medium Pressure Condensate | |
| MPS | Medium Pressure Steam | |
| MU | Make-Up Water | |
| N2 | | Nitrogen Gas |

| Code | Commodity - Water | Commodity - Wastewater |
| --- | --- | --- |
| N2L | | Nitrogen Liquid |
| NG | Natural Gas | Natural Gas |
| NPH | | Non-Potable Water - Hot |
| NPT | | Non-Potable Water - Tempered |
| NPW | | Non-Potable Water<br>(Potable Water segregated by backflow preventer and for general use such as hose bibs and pump seals) |
| OA | | Outdoor Air |
| O2 | | Oxygen Gas |
| 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 |
| RA | | Return Air |
| RAS | | Return Activated Sludge |
| RD | Roof Drain | |
| RS | | Raw Sewage |
| RW | Raw Water | Rain/Roof Water |
| RWL | Rain Water Leader | |
| SA | | Supply Air |
| SAM | Sample | Sample |
| SAN | Sanitary Drainage | Sanitary Drainage |
| SBS | Sodium Bisulphite | Sodium Bisulphite |
| SC | | Scum |

| Code | Commodity - Water | Commodity - Wastewater |
|---|---|---|
| SCA | Sulphuric Acid | |
| SCB | | Sodium Carbonate (Soda Ash) |
| SCD | | Scum - Dewatered |
| SCP | | Scum - Primary |
| SCRS | | Screened Raw Sewage |
| SCS | | Screenings |
| SDR | Saturated Recycle Water | |
| SE | | Secondary Effluent |
| SEA | | Service Air |
| SHC | Sodium Hypochlorite | Sodium Hypochlorite |
| SHD | | Sodium Hydroxide |
| SLC | | Sludge Cake |
| SLH | | Sludge – Hauled |
| SLI | | Sludge - Dewatered |
| SLO | Seal Oil | |
| SLP | | Sludge – Phosphorus Released |
| SLS | | Sludge - Screened |
| SLU | Sludge | |
| SND | | Sand (solid) |
| SNS | | Sand Slurry |
| SPD | Sump Pump Discharge | Obsolete (was Sump Pump Discharge)<br>Use SAN or LDS. |
| SRS | | Storm Relief Sewer |
| SSC | | Scum - Secondary |
| STD | Salt Dry | |
| STS | | South End Thickened Sludge |
| SUB | | DAF Subnatant |
| SUP | Supernatant | |
| SVT | | Struvite |
| SW | Seal Water | Seal Water (only used for separately derived systems. Typically NPW is utilized for seal use). |
| SWD | Stormwater Drainage | |
| TBS | | Thickened Bottom Sludge |
| TCE | | Treated Centrate |
| TDW | Tempered Domestic Water | Tempered Domestic Water |
| TFS | | Thickened Fermented Sludge |

| Code | Commodity - Water | Commodity - Wastewater |
|---|---|---|
| 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 |
| WA | | Waste Air |
| WAS | | Waste Activated Sludge |
| WS | Softened Water | |
| WSF | | Waste Activated Sludge Filtrate |
| WWS | | Wastewater Sewer |

### 5.1.3 Piping Material

**Table 5-3 : Piping and Tubing Material**

| Designation | Description |
|---|---|
| AL | Aluminum and Alloys |
| BA | Aluminum Bronze |
| GS | Galvanized Carbon Steel |
| CS | Carbon Steel |
| CU | Copper |
| DI | Ductile Iron |
| FP | Fiberglass Reinforced Plastic |
| KB | Concrete |
| PA | ABS (Acrylonitrile-butadiene styrene) |
| PD | HDPE (High Density Polyethylene) |
| PF | PFA (Perfluoroalkoxy) |
| PK | PVDF (Polyvinylidene Fluoride, i.e. Kynar®) |
| PP | PP (Polypropylene) |
| PV | PVC (Polyvinyl Chloride) |
| SS | Stainless Steel |

### 5.1.4 Insulation Material / Type

**Table 5-4 : Insulation Material / Type**

| Designation | Description |
|---|---|
| E | Elastomeric - flexible pipe insulation, closed cell structure (ASTM C534) |
| F | Fibreglass, UL-rated, preformed, sectional rigid with factory applied, Kraft paper with aluminum foil vapor barrier jacket |
| G | Cellular glass. |
| M | Mineral fibre (ASTM C553). |
| S | Calcium Silicate (ASTM C533) |

## 5.2 Piping and Duct Components

### 5.2.1 Manual Valve Identifier Format – Minor Valves

The identification format for minor manual valves (and dampers), without instrumentation, is as follows.

| FFFF | - | HV | - | A | NN(N)(N) | S |
|---|---|---|---|---|---|---|
| Facility Code (Optional) | - | Manual Valve Designation | - | Area Code | 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.

HV — is the Manual Valve Designation.

A — is the *Area Code*, which is based on Section 2.3.

NN(N)(N) — is the *Equipment Number* of the associated equipment. If no equipment is associated, allocate an *Equipment Number* specific for the applicable valve or group of valves.

S — is the *Suffix*, a single letter to designate the specific valve. Always apply a suffix, regardless if there are one or more valves with the same equipment number. Where there are insufficient letters (A-Z), double letters may be utilized (AA through ZZ). The requirement to utilize double letters should be rare.

*Notes:*

1. *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.*
2. *Large valves and controlled valves will be identified via the instrumentation standard identified in Section 7.1.*
3. *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 area, associated with pump P-G201. |
| HV-M645B | A manual valve in the M area. |
| HV-R102A | A manual valve in the R area. |

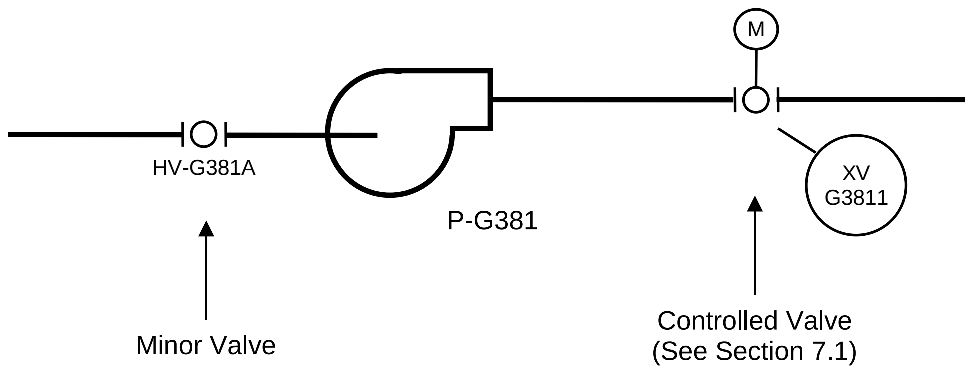



**Figure 5-1 : Valve Identification**

## 5.2.2 Manual Valve Identifier Format – Major Valves and Valves with Instrumentation

The identification format for major valves (and dampers) and any manual valve (and damper) with instrumentation, is based upon the instrumentation standard identified in Section 7.1. The format of the identifier is as follows.

| **FFFF** | **-** | **HV** | **-** | **A** | **NN(N)(N)** | **T** |
|---|---|---|---|---|---|---|
| Facility Code (Optional) | - | Manual Valve Designation | - | Area Code | Equipment Number | Instrument Number |
| | | | | | Loop 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.

HV — is the Manual Valve Designation.

A — is the *Area Code*, which is based on Section 2.3.

NN(N)(N) — is the *Equipment Number* of the associated equipment. If no equipment is associated, allocate an *Equipment Number* specific for the applicable valve or group of valves.

T — is the *Instrument Number*, where the number increments from the number 1 through 9. Use of the number 0 should be infrequent, reserved for special instruments or those where the instrument ending with 0 is a common instrument that serves other instruments.

NN(N)(N)T — is the Loop Number, comprised of the *Equipment Number* together with the *Instrument Number*.

Examples:

HV-G2011 — A manual valve in the G area, associated with pump P-G201, and contains open and closed limit switches.

HV-M6451 — A manual valve in the M area, with a position transmitter.

HV-R1022 — A manual valve in the R area, with a limit switch.

UT-S1510 — A multi-variable transmitter that connects to multiple sensors from various loops. Note the use of the 0 for the Instrument Number for this special case where it is handling multiple loops.

### 5.2.3 Manual Valve Identifier Format – Instrumentation Isolation and Bypass Valves

The identification format for minor instrumentation isolation and bypass valves, is as follows. Identification of simple, small isolation valves (i.e. gauge pressure transmitter) is not mandatory.

| **FFFF** | **-** | **HV** | **-** | **A** | **NN(N)(N)** | **T** | **S** |
|---|---|---|---|---|---|---|---|
| Facility Code (Optional) | - | Manual Valve Designation | - | Area Code | Equipment Number | Instrument Number | Suffix |
| | | | | | Loop 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.

HV — is the Manual Valve Designation.

A — is the *Area Code*, which is based on Section 2.3.

NN(N)(N) — is the *Equipment Number* of the associated equipment.

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.

NN(N)(N)T — is the Loop Number, comprised of the *Equipment Number* together with the *Instrument Number*.

S — is the *Suffix*, a single letter to designate the specific valve. Always apply a suffix, regardless if there are one or more valves with the same equipment number. Where there are insufficient letters (A-Z), double letters may be utilized (AA through ZZ). The requirement to utilize double letters should be rare.

*Notes:*

1. *The Loop Number will typically be the nearest associated instrument. In some cases, Loop Numbers may be designated for allocation of manual valves.*

### 5.2.4 Miscellaneous Piping Equipment Identifier Format

Miscellaneous piping equipment, which includes the following:

- Balancing Valves (Manual and Automatic)
- Check Valves
- Strainers
- Pressure Regulators (Pressure Control Valves)
- Pressure Safety Valves
- Stop Logs

are to be identified as follows:

| **FFFF** | **-** | **EEE** | **-** | **A** | **NN(N)(N)** | **S** |
| --- | --- | --- | --- | --- | --- | --- |
| Facility Code (Optional) | - | Equipment Functional Designation | - | Area Code | 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. |
| A | is the *Area Code*, which is based on Section 2.3. |
| NN(N)(N) | 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 miscellaneous piping equipment.*
2. *Miscellaneous Piping 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. *Miscellaneous equipment with significant instrumentation will be identified via the instrumentation standard identified in Section 7.1.*

Examples:

| | |
|---|---|
| BVA-K302B | An automatic balancing valve in the K area. |
| CV-G201A | A check valve in the G area, associated with pump P-G201. |
| CV-M645B | A check valve in the M area. |
| STR-R102A | A strainer in the R area. |
| SL-K151A | A stop log in the K area. |

### 5.2.5 Miscellaneous Ducting Equipment Identifier Format

Miscellaneous duct equipment, which includes the following:

- Balancing Dampers (Manual and Automatic),
- Back-draft Dampers,
- Fire Dampers, and
- Smoke Dampers

are to be identified as follows:

| **FFFF** | **-** | **EEE** | **-** | **A** | **NN(N)(N)** | **S** |
|---|---|---|---|---|---|---|
| Facility Code (Optional) | - | Equipment Functional Designation | - | Area Code | 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. |
| A | is the *Area Code*, which is based on Section 2.3. |
| NN(N)(N) | 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 miscellaneous ducting equipment.*
2. *Balancing dampers, backdraft dampers, and fire dampers may utilize common equipment numbers and suffixes. For example, it is acceptable to have a BD-G638A and a BDD-G638A.*
3. *Where balancing dampers are integrated with the grille / diffuser, identify as the grille / diffuser (i.e. GRD-M645-1).*
4. *Miscellaneous ducting equipment with significant instrumentation will be identified via the instrumentation standard identified in Section 7.1.*

Examples:

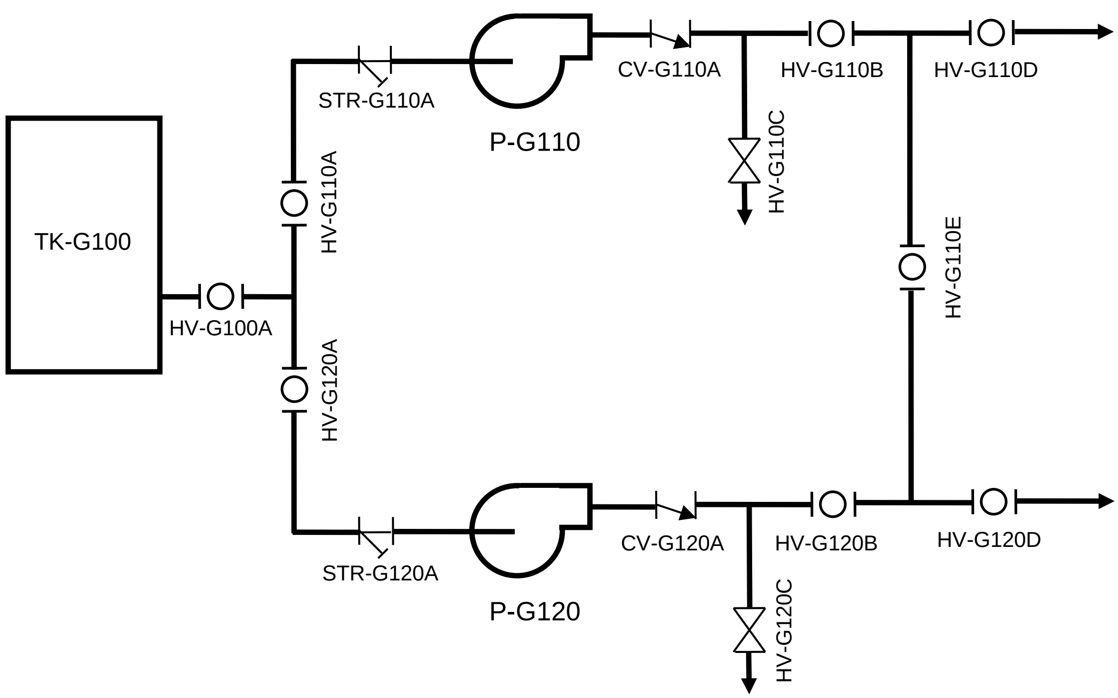
| | |
|---|---|
| BD-K602B | The second balancing damper in the K area associated with AHU-K602. |
| BDD-G601A | A back-draft damper in the G area, associated with air handling unit AHU-G601. |
| FD-M645B | The second fire damper in the M area associated with AHU-M645. |
| SD-M645D | The fourth smoke damper in the M area associated with AHU-M645. |

### 5.2.6 Cathodic Protection Components

The identification of cathodic protection system elements is to be developed at a later date.

### 5.2.7 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**

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# 6 ELECTRICAL

## 6.1 Equipment Identifier Format

The identification format for electrical equipment is as follows.

| FFFF | - | EEEE | - | A | NN(N)(N) | T | - | S |
|---|---|---|---|---|---|---|---|---|
| Facility Code (Optional) | - | Equipment Functional Designation | - | Area Code | 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. |
| A | is the *Area Code*, which is based on Section 2.3. |
| NN(N)(N) | 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-M7210 | A MCC located in the M 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 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 | Contactor | |
| CP | Control Panel | Includes miscellaneous electrical control panels, such as a heat trace 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) | |
| EDP | Electrical Device Panel | Use for metering panels, protection panels and other miscellaneous electrical panels. |
| 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 | |
| INV | Inverter | |
| JB | Junction Box | |

| Functional Designation | Description | Notes |
|---|---|---|
| K | Interlocking Key (Kirk Key) | See Section 6.4.5 |
| LC | Lighting Contactor | A lighting control panelboard would be identified as a PNL.. |
| 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. |
| RCFR | Rectifier | |
| RCPT | Receptacle | |
| RCTR | Reactor | Includes VFD line and load reactors. |
| RLY | Protection Relay | |
| ~~SCR~~ | ~~Silicon Controlled Rectifier~~ | Utilize RCFR |
| 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** | **-** | **A** | **NN(N)(N)** | **-** | **KK** | **S** | **-** | **MM** |
|---|---|---|---|---|---|---|---|---|
| Receptacle Designation | - | Area Code | Equipment Number of Source Panel | - | Circuit Number | Switched Sub-Circuit (Optional) | - | Incrementing Number (Optional) |

Where,

| | |
|---|---|
| RCPT | is the receptacle designation. |
| A | is the *Area Code*, which is based on Section 2.3. |
| NN(N)(N) | 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. |

The RCPT designation may be implied on plan drawings, as shown in Figure 6-1 below.


**Figure 6-1 : Receptacle Identification on Plan Drawings**

## 6.4.2 Power Cables Associated with Identified Equipment

The identification format for power cables is as follows.

| C | - | A | NN(N)(N) | - | S |
|---|---|---|---|---|---|
| Cable Designation | - | Area Code | 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.

A — is the *Area Code*, which is based on Section 2.3.

NN(N)(N) — 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** | **NN(N)(N)** | **-** | **KK** | **S** |
|---|---|---|---|---|---|---|
| Cable Designation | - | Area Code | Equipment Number of Source Panel | - | Circuit Number | Switched Sub-Circuit (Optional) |

Where,

| | |
|---|---|
| C | is the Cable Designation. |
| A | is the *Area Code*, which is based on Section 2.3. |
| NN(N)(N) | 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 | - | A | NN(N)(N) | T | - | S |
|---|---|---|---|---|---|---|
| Junction Box Designation | - | Area Code | Equipment Number | Circuit Number | - | Suffix (Optional) |

Where,

| | |
|---|---|
| JB | is the Junction Box designation. |
| A | is the *Area Code*, which is based on Section 2.3. |
| NN(N)(N) | 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 6.3. |
| 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. *Area Codes are not utilized as key interlocks could span over multiple 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.

| **A** | **NN(N)(N)** | **-** | **CC** | **S** |
|---|---|---|---|---|
| Area Code | Equipment Number of Source | - | Circuit Number or Neutral Designation | Switched Sub-Circuit (Optional) |

Where,

A is the *Area Code*, which is based on Section 2.3.

NN(N)(N) is the *Equipment Number* of the source panelboard.

CC 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 | NN(N)(N) | - | C | S | D |
|---|---|---|---|---|---|
| Area Code | Equipment Number of Source | - | Circuit Number | Switched Sub-Circuit (Optional) | Power Designation |

Where,

| | |
|---|---|
| A | is the *Area Code*, which is based on Section 2.3. |
| NN(N)(N) | 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.

| **A** | **NN(N)(N)** | **-** | **X** | **H** |
|---|---|---|---|---|
| Area Code | Equipment Number | - | Sequence Number (Optional) | Phase |

Where,

A is the *Area Code*, which is based on Section 2.3.

NN(N)(N) 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.

W1511-2B Phase B conductor of the second power circuit associated with centrifuge CE-W1511 at the NEWPCC facility.

\- 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:

| A | NN(N)(N) | - | WWW | S |
|---|---|---|---|---|
| Area Code (Optional) | Equipment Number (Optional) | - | Wire Number | Suffix (Optional) |

Where,

| | |
|---|---|
| A | is the *Area Code*, which is based on Section 2.3. It is not required for wires exclusively within the motor starter. |
| NN(N)(N) | 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:*

1. *It is desirable, but not mandatory, that the wire number in a motor starter match the terminal number.*
2. *It is deemed acceptable to omit the Area Code 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. |

## 6.5 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 | |
| CB | Circuit Breaker | |
| CON | Contactor | |
| CPT | Control Power Transformer | |
| CR | Control Relay | |
| CT | Current Transformer | Phase identification may be utilized as part of the subcomponent identifier. i.e. CT-1A, CT-1B |
| 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 | |
| PT | Potential Transformer | Phase identification may be utilized as part of the subcomponent identifier. i.e. PT-1A, PT-1B |
| RCFR | Rectifier | |
| RCTR | Reactor | |
| RLY | Protection Relay | Utilize IEEE Number for suffix if appropriate. |
| ~~SCR~~ | ~~Silicone Controlled Rectifier~~ | Utilize RCFR |
| 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.CB | Circuit Breaker for Motor Control Centre MCC-P011 TVSS |

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.

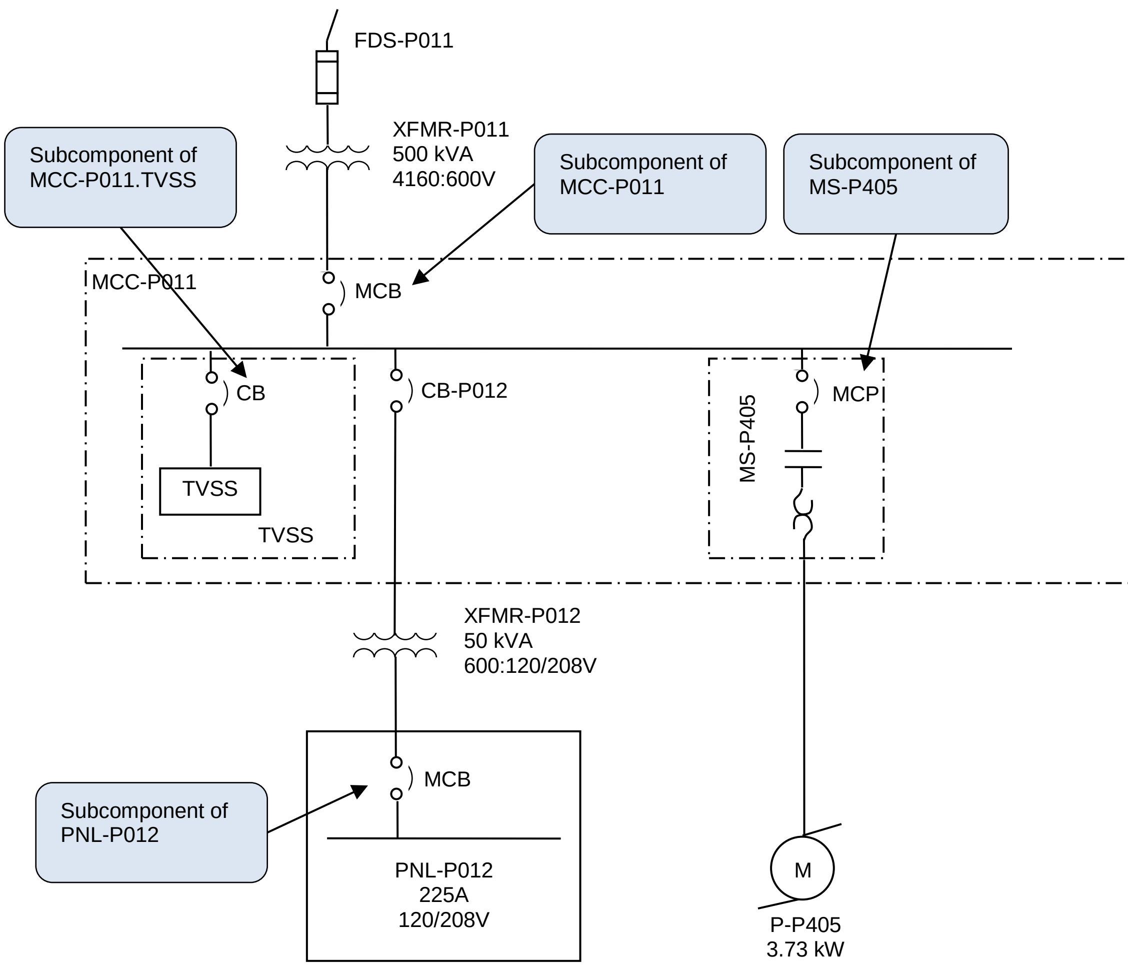



**Figure 6-2 : Subcomponents – Electrical Equipment**

### 6.5.1 Tie Circuit Breakers

Tie breakers are used to connect electrical buses together. Tie breakers are considered to be subcomponents of the switchgear / panel that they are located in. The identification format for tie circuit breakers is in accordance with Section 2.6, except that the letter T is used instead of a number for the component number.

Examples:

| | |
|---|---|
| SGR-U701.CB-T | A tie breaker between SGR-U701 and SGR-U002 |
| SGR-P711.CB-T | A tie breaker between SGR-P711 and SGR-P712 |

illustrates a sample electrical single line diagram with tie breakers.

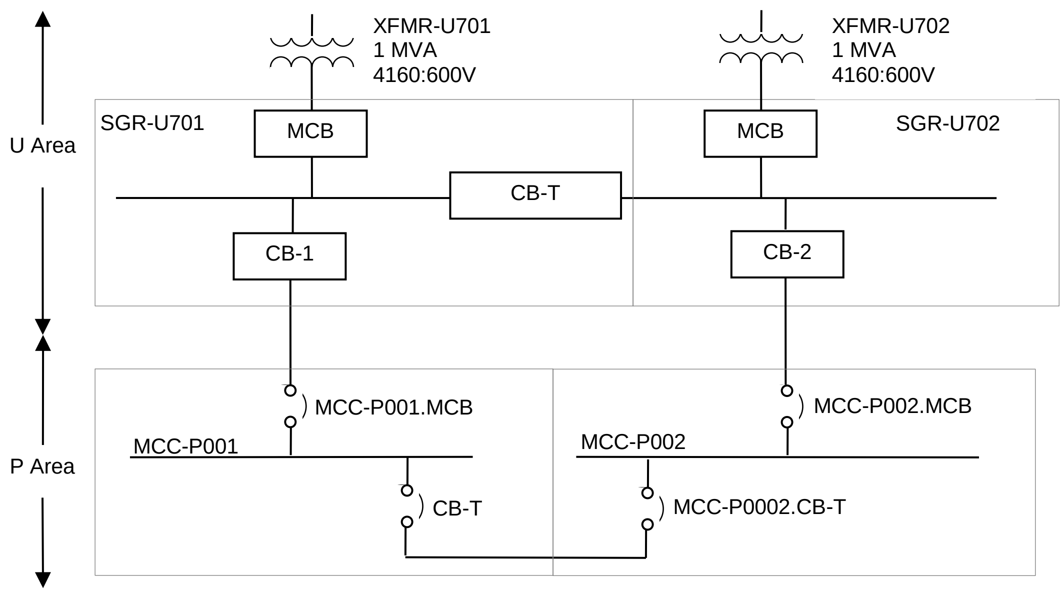



**Figure 6-3 : Sample Tie Breaker Identification**

*Note:*

1. *All breakers in Figure 6-3, whether specifically shown or not, are subcomponents.*

## 6.6 Examples

### 6.6.1 Example 1

An example single line diagram is shown in Figure 6-4.

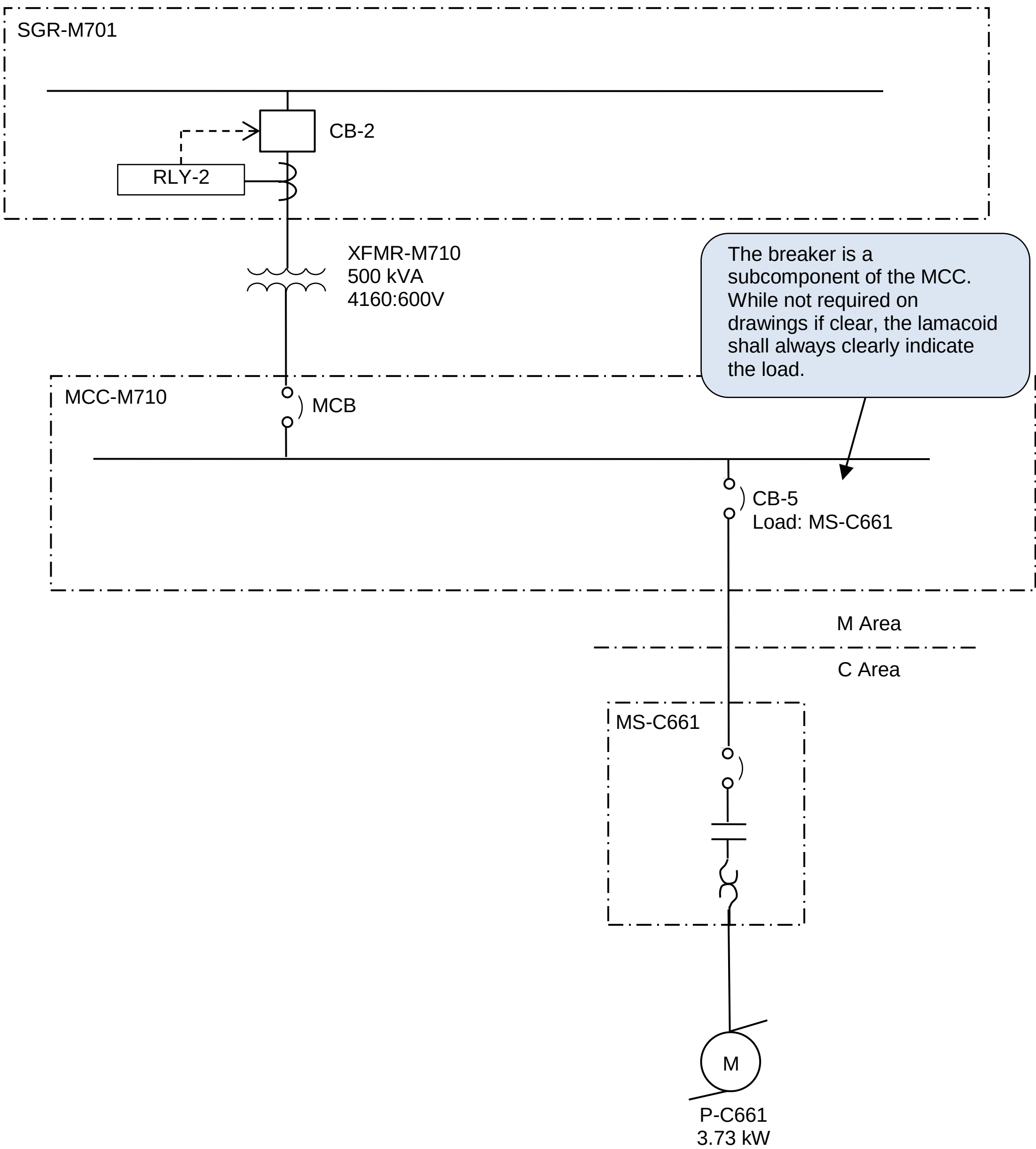



**Figure 6-4 : Example Identification by Load Equipment**

# 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.

<table>
<tr><th>FFFF</th><th>-</th><th>FAS</th><th>-</th><th>A</th><th>-</th><th>L</th><th>RR</th><th>-</th><th>D</th><th>NN</th></tr>
<tr><td rowspan="2">Facility Code (Optional)</td><td rowspan="2">-</td><td rowspan="2">Fire Alarm Design-ation</td><td rowspan="2">-</td><td>Area Code</td><td>-</td><td>Level</td><td>Room Number</td><td rowspan="2">-</td><td rowspan="2">Device Designation</td><td rowspan="2">Device Number</td></tr>
<tr><td colspan="4">From Room Number Designation</td></tr>
</table>

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.

A — is the *Area Code*, which is based on Section 2.3.

L — is the *Level*, which shall typically be one or two characters, as described in Section 3.1.

RR — is the *Room Number*, which shall be assigned as described in Section 3.1.

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 area.

FAS-M-222-A02 — The second horn/strobe in room 22 on the second floor of the M 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 6-5 below. Note a significant portion of the device identifier is determined via context. Where the context is not clear, use full device identifiers.

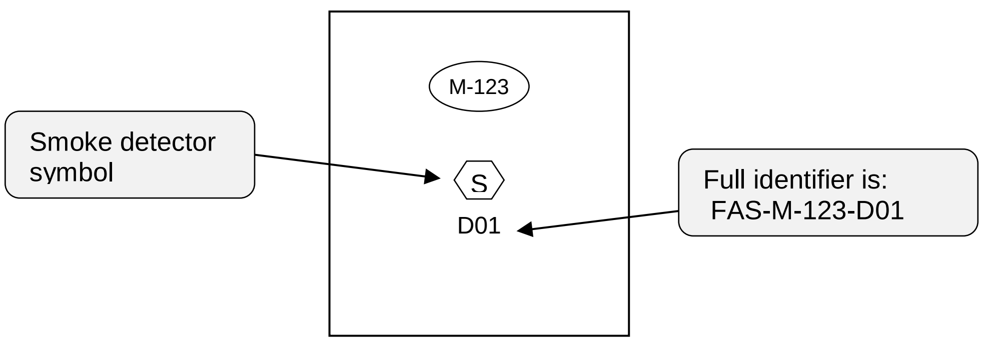



**Figure 6-5 : Room Numbering on Drawings – Plan View**

### 6.7.4 Wire Tags

The identification format for fire alarm circuits is as follows.

| **A** | **NN(N)(N)** | **-** | **TTT** | **-** | **CC** |
|---|---|---|---|---|---|
| Area Code | Equipment Number of Source Panel | - | Type of Circuit | - | Circuit Number |

Where,

A — is the *Area Code* of the source panel or equipment. Typically, this will be the fire alarm control panel, but it could also be a booster power supply.

NN(N)(N) — is the *Equipment Number* of the source panel or equipment.

TTT — is the *Type of Circuit*, selected as follows:

- DLC Data Communication Link
- IDC Initiating Device Circuit
- NAC Notification Appliance Circuit

CC — is the *Circuit Number*, an incrementing number.

Examples:

P901-NAC-01 Notification appliance circuit 01 out of FACP-P901.

R921-NAC-02 Notification appliance circuit 02 out of BPS-R921.

P901-DLC-03 Digital Communication Link circuit 03 out of FACP-P901.

# 6.8 Security Devices

The identification of security system components is dependent upon the system that the device is connected to. If the security device is connected to a dedicated security system, it shall be identified as per this section. However, devices directly connected to the process control system (i.e. PLC) shall be identified as per Section 7.1.

## 6.8.1 Device Identifier Format

The security device identifier format 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** | **-** | **A** | **-** | **L** | **RR** | **S** | **-** | **DD** | **N** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Facility Code (Optional) | - | Security Design-ation | - | Area Code | - | Level | Room Num | Suffix (Opt) | - | Device Design -ation | 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. |
| A | is the *Area Code*, which is based on Section 2.3. |
| L | is the *Level*, which shall typically be one or two characters, as described in Section 3.1. For outdoor locations, it is recommended that the EX designation be utilized, as described in Section 3.1. |
| RR | is the *Room Number*, which shall be assigned as described in Section 3.1. |
| S | is the Suffix (optional), which corresponds to the Door Identifier for security devices associated with doors |
| DD | is the Device Designation, which is comprised of two letters from Section 6.8.2. |
| N | is the *Device Number*, which uniquely identifies a specific device within a room. |

Examples:

| | |
|---|---|
| SCY-S-115B-DC1 | The first door switch in on door B of room 15 on the main level of the Secondary Clarifier area. |
| SCY-M-222-AH2 | The second horn/strobe in room 22 on the second floor of the M area. |
| SCY-S-115A-CR1 | The access card reader outside the door (A) to room 15 on the main level of the Secondary Clarifier area. |
| SCY-A-EX1-VC1 | An outdoor video camera in the A 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/Door Specific**

| **Device Designation** | **Description** | **Type Modifiers** *(See Note 2)* |
|---|---|---|
| AH | Annunciation Device (Horn / Strobe) | H Horn<br>S Strobe |
| CR | Access Card Reader (See Note 1) | |
| DC | Door Contact | |
| EL | End-of-line Device | |
| ES | Electric Strike (Subcomponent of Door) | |
| EX | Exit Button | Includes “Request to Exit” and crash bars. |
| GB | Glass-Break Contact | |
| IM | Addressable Monitor / Input Module | |
| IS | Isolation Module | |
| KP | Keypad | |
| MD | Motion Detector | |
| PB | Panic Button | |
| VC | Camera | FM Flush Mount<br>PTZ Pan/Tilt/Zoom<br>SM Surface Mount |

*Note:*

1. *Access Card Readers will be designated by the door identifier.*
2. *Show the type modifier next to the device as applicable.*

### 6.8.3 Security Equipment Designations

Some security equipment is preferably 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 |
|---|---|
| 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.*

## 6.8.5 Wire Tags

The identification format for security circuits is as follows.

| **A** | **NN(N)(N)** | **-** | **TTT** | **-** | **CC** |
|---|---|---|---|---|---|
| Area Code | Equipment Number of Source Panel | - | Type of Circuit | - | Circuit Number |

Where,

A — is the *Area Code* of the source panel or equipment. Typically, this will be the fire alarm control panel, but it could also be a booster power supply.

NN(N)(N) — is the *Equipment Number* of the source panel or equipment.

TTT — is the *Type of Circuit*, selected as follows:

- DLC Data Communication Link
- IDC Initiating Device Circuit
- NAC Notification Appliance Circuit

CC — is the *Circuit Number*, an incrementing number.

*Note:*

*1. The Type of Circuit requires review. The Designer may propose alternate types to the City for review and approval.*

Examples:

P951-NAC-01 Notification appliance circuit 01 out of SCP-P901.

P951-DLC-03 Digital Communication Link circuit 03 out of SCP-P901.

# 7 AUTOMATION

## 7.1 Instrumentation

### 7.1.1 Instrument Identifier Format

The identification format for instrumentation is as follows.

| **FFFF** | **-** | **XXXX** | **-** | **A** | **NN(N)(N)** | **T** | **-** | **S** |
|---|---|---|---|---|---|---|---|---|
| Facility Code (Optional) | - | Instrument Functional Designation | - | Area Code | Equipment Number | Instrument Number | - | Suffix |
| | | | | | Loop 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.

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.

A — is the *Area Code*, which is based on Section 2.3.

NN(N)(N) — 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.

NN(N)(N)T — 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. The NEWPCC facility will utilize five 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.

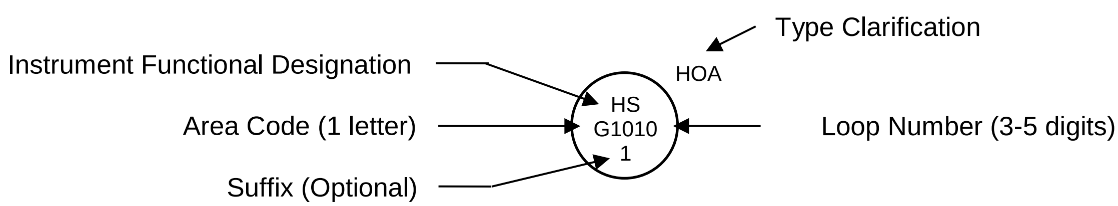
0650-PT-M3011 — A pressure transmitter associated with pump M301 at the Hurst Pumping Station. Note that the facility code is optional.

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. |
| FV-R12311 | A flow valve at the NEWPCC facility, with five digit loop numbers. |
| ZSS-F3212 | A safety switch for CNV-F321. |
| HS-L010 | A start pushbutton for P-L01 at a wastewater lift station. |
| PG-S1102 | A pressure gauge for pump P-S110. |

### 7.1.2 Drawing Format

The format for instrumentation on drawings, such as P&IDs, is shown below:



### 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 (15) |
| I | Current | | Indicate (5) | | |
| J | Power | | Scan | | |
| K | Time, Schedule | Time Rate of Change | | Control Station | |
| L | Level | | Light (6) | | Low (16) |
| 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 | |

*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. In addition, do not use the C controller designation for switches that directly control a device or equipment. For example, a unit heater on/off thermostat would be a TS, not a TC.*
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.*
15. *Where more than one switch or alarm within the same control loop is designated with a High designation, the second switch or alarm (at a higher level) shall be designated with a High-High designation. An instrument shall not be designated with a High-High designation unless there is an instrument with a High designation already present. For example: A LSH is a first level switch at a high level and a LSHH would be a second level switch at a higher level. Either switch may have associated alarms or interlocks.*
16. *Where more than one switch or alarm within the same control loop is designated with a Low designation, the second switch or alarm (at a lower level) shall be designated with a Low-Low designation. An instrument shall not be designated with a Low-Low designation unless there is an instrument with a Low designation already present. For example: A LSL is a first level*

*switch at a low level and a LSLL would be a second level switch at a lower level. Either switch may have associated alarms or interlocks.*

**Table 7-2 : Common Instrument Functional Designations**

| Designation | Direct Translation | Example |
|---|---|---|
| AA | Analysis Alarm | Gas detection horn / strobe |
| AAH | Analysis High Alarm | $H_2S$ gas detection high level alarm |
| AT | Analysis Transmitter | $H_2S$ 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 |

| Designation | Direct Translation | Example |
|---|---|---|
| ME | Moisture Sensor | Moisture sensor. Includes submersible pump/mixer leakage detector. |
| 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. |
| 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. The switch may be associated with process control, interlock, alarm or any combination thereof. |
| TSLL | Temperature Switch – Low-Low | A second low temperature switch that has a setpoint lower than the first low temperature switch. The switch may be associated with process control, interlock, alarm or any combination thereof. |
| 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 |
| YS | Presence Detector | Use for motion detectors that are connected to the process control system and not to a security system. Use Section 6.8 for security systems. |
| ZSC | Position - Closed | Valve closed limit switch |
| ZSO | Position - Open | Valve opened limit switch |
| ZT | Position Transmitter | Linear position transmitter |

### 7.1.4 Loop Numbers

The equipment number (2-4 as applicable) digits of a loop number shall be identical to the equipment with which the instrument is associated.

Motor controls of motorized equipment should have an *Instrument Number* of 0. For example, a local start/stop switch for pump P-S305 should be designated as HS-S3050 or with a suffix such as HS-S3050-2. Nothing precludes the use of a 0 *Instrument Number* for instruments not associated with motorized equipment.

The *Loop Number* should generally be unique for each instrument loop. For example, outdoor air, mixed air, and supply air temperature transmitters on an air handling unit should all have different loop numbers as they are measuring different temperatures.

Exceptions will only be permitted where:

- The two instrument loops are performing the identical function. For example, two thermal dispersion flowmeters measuring the same point and being averaged in software should utilize the same loop number with different suffixes.
- No other good alternatives exist. Note that use of a common loop number for multiple loops will require careful attention in wiring and signal tagging.

### 7.1.5 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 | Coriollis 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 |

## 7.1.6 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.

### 7.1.6.1 Manual Valves

All manual valves are to be identified as HV, as per Sections 5.2.1, 5.2.2 and 5.2.3.

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 7.1.6.4 and 7.1.6.5.

Instrument isolation valves less than or equal to 12mm do not require identification if there is no requirement to identify them in an operations procedure.

### 7.1.6.2 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. For example, this could be a Foundation Fieldbus Controlled valve. A valve that has flow as it's initiating variable, but receives a position signal from an external controller is **not** a FCV, but a FV (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. For example, this could be a Foundation Fieldbus Controlled valve with an integral PID controller. A valve that controls pressure, but receives a position signal from an external controller is **not** a PCV (as per ISA 5.1). Note that while a mechanical pressure regulator is functionally identified as a PCV, it is identified as per 5.2.3.

### 7.1.6.3 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 *Flow Valves*, as per ISA 5.1. Only valves that have a control loop with flow as the initiating variable are *Flow Valves*.

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 *Flow Valve* if the initiating variable is *Level*.

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 *Flow Valve* if the initiating variable is *Pressure.*

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 *Flow Valve* if there are multiple initiating variables.

#### 7.1.6.4 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. |

#### 7.1.6.5 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. |

### 7.1.7 Multi-Function Instruments

Each discrete physical instrument shall only be given one instrument identifier, regardless of the number of functions within that instrument. For example, a submersible pump protection relay may have a temperature relay and a leak detection relay within one device. The instrument would be identified with a single identifier and a functional designation of UY. If it is desired to show the specific functionality of the instrument, then the subcomponent format described in Section 7.6 shall be utilized.

### 7.1.8 Additional Clarifications

#### 7.1.8.1 Submersible Pumps and Mixer Leak Detection

Submersible pump and mixer leak detection sensors shall be identified with a functional designation of ME (Moisture Element).

#### 7.1.8.2 Temperature Transmitters

Temperature transmitters with integrated temperature elements shall be identified with a functional designation of TT or TIT. In the event that the integrator temperature element of the temperature transmitter requires identification, utilize the subcomponent format (i.e. S682-TT.TE). On P&IDs, do not show the temperature element if integrated with the temperature transmitter. Refer to Figure 7-1 for examples.

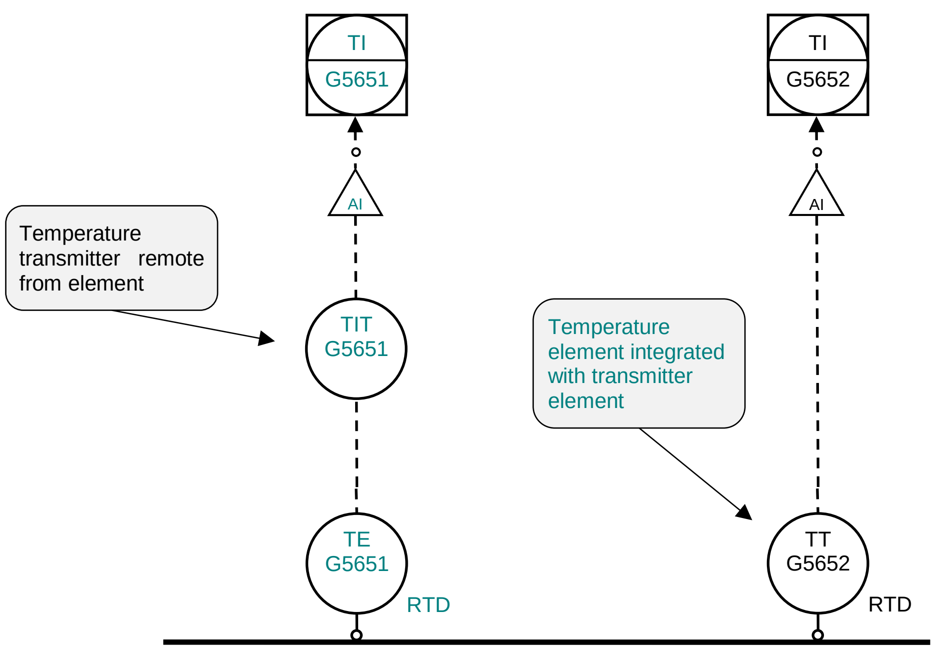



**Figure 7-1: Example Temperature Transmitters**

# 7.2 Automation Equipment

## 7.2.1 Identifier Format

The identification format for automation equipment, other than instrumentation, is as follows.

| FFFF | - | EEEE | - | A | NN(N)(N) | - | S |
|---|---|---|---|---|---|---|---|
| Facility Code (Optional) | - | Equipment Functional Designation | - | Area Code | 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. |
| A | is the *Area Code*, which is based on Section 2.3. |
| NN(N)(N) | 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-G8101 | A PLC located in the Grit 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-G851 | A junction box not associated with a specific mechanical unit of equipment, and thus numbered in the 800 series equipment numbers. |
| 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 / Cabinet | |
| 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 | |
| LHMI | Standalone Human Machine Interface (HMI) Terminal | e.g. local touchscreens |
| ISB | Intrinsic Safety Barrier | Typically only a subcomponent. |
| JBA | Junction Box (Automation) | |
| LCP | Local Control Panel | |
| PLC | Programmable Logic Controller | |
| PRN | Printer | |
| RIO | Remote I/O | |
| RTU | Remote Terminal Unit | |
| TB | Terminal Block | Subcomponent only. |

*Notes:*

1. *Avoid overlap of Automation Equipment Functional Designations with Electrical, Mechanical, or Process Functional Designations.*

### 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** | **-** | **A** | **NN(N)(N)T** | **-** | **S** |
|---|---|---|---|---|---|
| Cable Designation | - | Area Code | Loop Number of Instrumentation | - | Suffix (Optional) |

Where,

CA — is the *Cable Designation*, which for automation cables is comprised of the letters CA.

A — is the *Area Code*, which is based on Section 2.3.

NN(N)(N)T — 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.

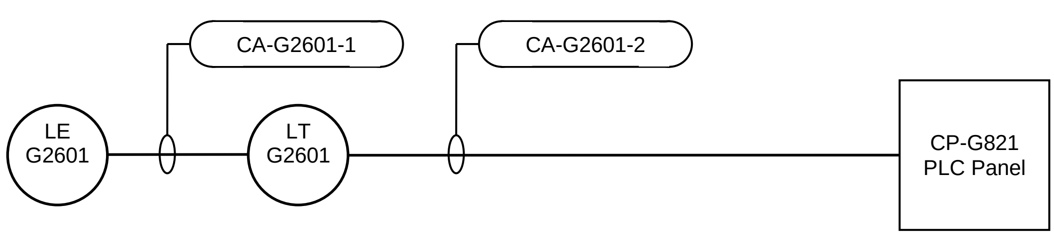



**Figure 7-2: Instrument Cable Identification Example – Level Transmitter**

### 7.3.2 Cables Associated with Identified Equipment

The identification format for automation cables is as follows.

| CA | - | A | NN(N)(N) | - | S |
|---|---|---|---|---|---|
| Cable Designation | - | Area Code | Equipment Number of Associated Equipment | - | Suffix (Optional) |

Where,

CA — is the *Cable Designation*, which for automation cables is comprised of the letters CA.

A — is the *Area Code*, which is based on Section 2.3.

NN(N)(N) — 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.

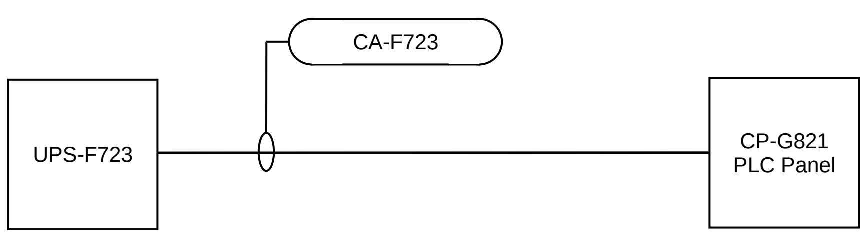



**Figure 7-3: Instrument Cable Identification Example – Identified Equipment**

## 7.4 Sample P&ID

A sample pump P&ID is provided below to illustrate typical conventions for identifying instrumentation.

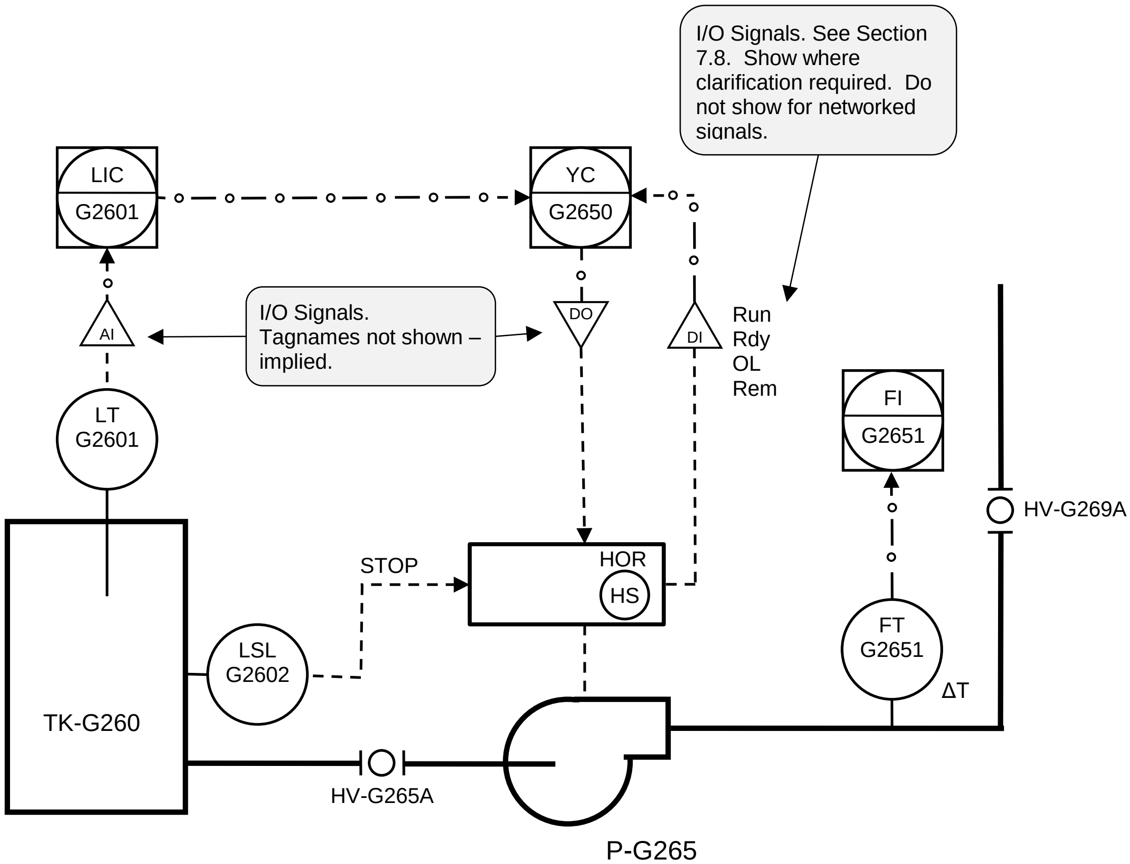



**Figure 7-4: Sample Pump P&ID**

# 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 FU-11.

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:

| A | NN(N)(N) | T | - | W | S |
|---|---|---|---|---|---|
| Area Code | Equipment Number | Instrument Number | - | Wire Number | Suffix (Optional) |
| | Loop Number | | | | |

Where,

A — is the *Area Code*, which is based on Section 2.3.

NN(N)(N) — 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.

NN(N)(N)T — 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:

| **A** | **NN(N)(N)** | **T** | **-** | **W** | **A** |
|---|---|---|---|---|---|
| Area Code | Equipment Number | Instrument Number | - | Wire Number (Optional) | Analog Designation |
| | Loop Number | | | | |

Where,

A — is the *Area Code*, which is based on Section 2.3.

NN(N)(N)T — 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** | **S** |
|---|---|---|---|---|---|---|
| I/O Designation | Rack Number (Optional) | | Module Number (Optional) | | I/O Number | Suffix Designation (Optional) |

Where,

DD is the *I/O Designation*, which is based on Table 7-6.

R is the *Rack Number*, which is typically one or two digits. A Rack Number is not applicable to all I/O systems.

M is the *Module Number*, which is typically one or two digits. A *Module Number* is not applicable to all I/O systems.

S is the *Suffix Designation*, if applicable, which is based on 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) |

**Table 7-7 : Suffix Designations**

| Suffix Designation | Description |
|---|---|
| C | Utilize for isolated DC discrete input modules to designate the specific common line. |
| L | Utilize for isolated output modules and relay modules to designate an AC incoming line. |
| N | Utilize for isolated AC discrete input modules to designate the specific neutral line. |
| P | Utilize for isolated output modules and relay modules to designate an DC incoming line. |
| + | Analog positive or incoming wire. |
| - | Analog negative or outgoing wire. |

*Notes:*

1. *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.*
2. *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. |
| Q3.2.5L | Incoming AC line signal for discrete output relay associated with rack 3, module 3, point 5. |

# 7.6 Subcomponents

## 7.6.1 Instrumentation 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 7-5. 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-G3811 |
| XV-G381.ZSC | The closed limit switch of the valve XV-G3811 |
| MS-6381.HS | The *Hand-Off-Remote* switch on motor starter MS-G381. |

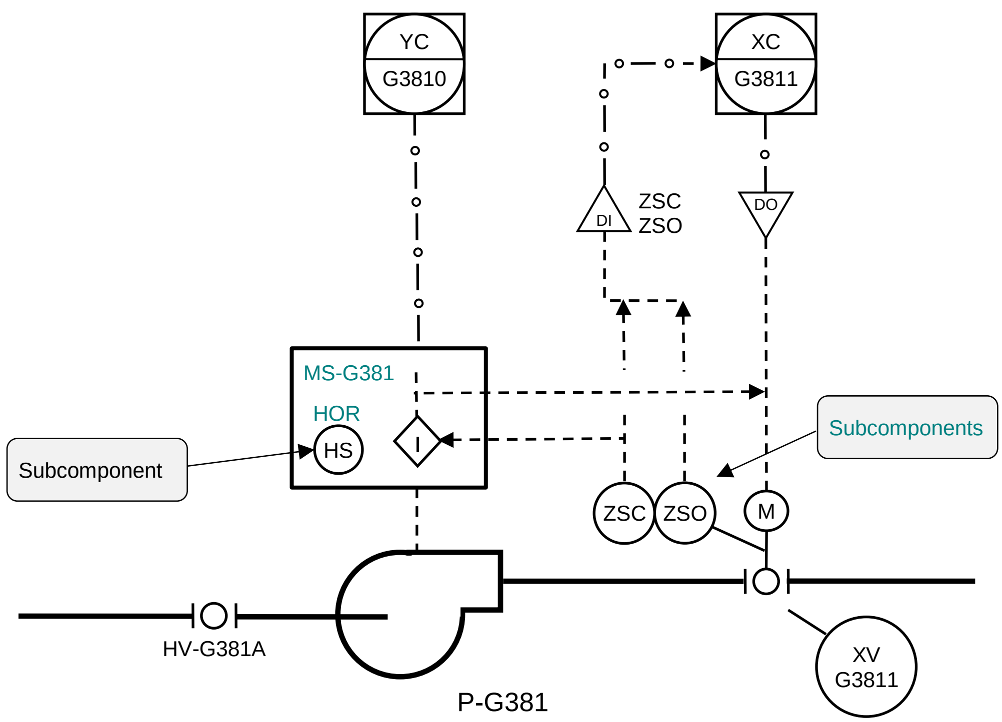



**Figure 7-5 : Subcomponents – Electrical and Instrumentation**

### 7.6.2 Panel Subcomponents

Devices within control panels, automation device panels, junction boxes, and other panels should typically be identified as subcomponents unless they are accessed separately from the containing panel. Examples of equipment not to be identified as subcomponents are shown in Table 7-8.

**Table 7-8 : Automation Equipment Not To Be Identified as Subcomponents**

| Functional Designation | Description |
|---|---|
| CS | Computer Server |
| CW | Computer Workstation - General |
| CWD | Computer Workstation - Development |
| CWO | Computer Workstation - Operator |
| GDC | Gas Detection Controller |
| LHMI | Standalone Human Machine Interface (HMI) Terminal |
| PLC | Programmable Logic Controller |
| PRN | Printer |
| RIO | Remote I/O |
| RTU | Remote Terminal Unit |

## 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 |
|---|---|---|---|---|
| Base Equipment / Instrument Identifier | . | Functional Signal Designation | | Suffix (Optional) |

Where,

E* is the *Base Equipment / Instrument Identifier*, based upon other parts of this document. See the examples for clarification.

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 7-9.

S is the optional *Suffix*, which is a number utilized to differentiate between multiple similar signals.

**Table 7-9 : Discrete Input Functional Signal Designations – Non ISA**

| Signal | Description |
|---|---|
| .Auto | Hand Switch Auto Position |
| .Byp | Hand Switch Bypass Position |
| .Flt | Faulted (See Note 5) |
| .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 |
| .RunHi | Motor Running High Speed |
| .RunLo | Motor Running Low Speed |
| .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.*
5. *Utilize Flt (Fault) rather than an overload designation for the signal coming from a motor overload. With current electronic overloads, multiple conditions other than just an overload can cause an alarm/trip and the fault designation is more appropriate.*

Examples:

| | |
|---|---|
| HSS-G1051 | Stop pushbutton signal from HSS-G1051, 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. |
| P-G105.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.Flt | 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.Flt | Fault signal associated with flow transmitter FT-S6021. |
| XV-S3810.ZSC | Closed limit switch signal from valve XV-S3810. |
| XV-S3810.Auto | Hand switch in auto signal from valve XV-S3810. |
| 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. |

**Acceptable Alternate**

In some cases, equipment may be complex, and it may be desired to associate all I/O directly with the source instrument / device / equipment, even for motor control. If this scheme is implemented, it is to be consistent across the facility. Note that this scheme is not currently accepted for wastewater facilities.

Example:

| | |
|---|---|
| HS-G1050.Rem | The switch in *Remote* signal from the *Hand-Off-Remote* switch HS-G105, which is associated with pump P-G105. In this alternate scenario, note that the Base Equipment / Instrument Identifier is the actual instrument rather than the associated equipment. A Functional Signal Designation is required to clarify the indicated specific switch position. |

## 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 7-10. |
| 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 7-10 : Discrete Output Functional Signal Designations**

| Signal | Description |
|---|---|
| .CmdRun | Run Command |
| .CmdRunHi | Run Command – High Speed |
| .CmdRunLo | Run Command – Low Speed |
| .CmdRst | Fault Reset Command |
| .CmdCls | Close Command |
| .CmdOpn | Open Command |
| .CmdEnb | Enable Command |
| .CmdExt | Extend Command (utilize for samplers) |
| .CmdRet | Retract Command (utilize for samplers) |

*Notes:*

1. *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.*
2. *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 and in this case will represent the specific output signal, not necessarily the loop identification.

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-M2151.CmdZ Valve position command signal from flow indicating controller FIC-M2151. Note that while the control loop is based on flow, the specific signal is a Z, driving the valve position.

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 destination of this signal is a boiler that has an integral dedicated controller.

HCE-B619.CmdJ Power command signal (in % of full power) to an electric heating coil controller. In the event that the signal represented a specific temperature setpoint, then the *Functional Variable* would be a T.

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 | - | A | NN(N)(N) | - | S |
|---|---|---|---|---|---|---|---|
| Facility Code (Optional) | - | Equipment Functional Designation | - | Area Code | 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. |
| A | is the *Area Code*, which is based on Section 2.3. |
| NN(N)(N) | 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 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 | |
| CNP | Network Cable - Patch | |
| JBN | Junction Box - Network | |
| MDM | Modem | |
| NAP | Network Access Point | |
| ND | Network Device | Utilize for general devices not otherwise in list. Example: network terminators |
| NFW | Network Firewall | |
| NGW | Network Gateway | |
| NJ | Network Jack | |
| NJT | Network Jack – Telephone | |
| NMC | Network Media Converter | |
| NP | Networking Panel / Cabinet | |
| NPP | Networking Patch Panel | |
| NRD | Network Radio | |
| NRP | Network Repeater | |
| NRT | Network Router | |
| NSP | Network Segment Protector | Typically used for PROFIBUS PA |
| NSW | Network Switch, Ethernet | |
| NT | Network Terminator | |

*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 | - | A | NN(N)(N) | - | S |
|---|---|---|---|---|---|
| Cable Designation | - | Area Code | Equipment Number of Associated Equipment | - | Suffix (Optional) |

Where,

CN — is the *Cable Designation*, which for network cables is comprised of the letters CN.

A — is the *Area Code*, which is based on Section 2.3.

NN(N)(N) — 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.

The following Appendices have been moved to a separate document titled *Identification Standard* Appendices managed by the Wastewater Planning and Project Delivery Branch.  To request a copy of the document, please contact the Wastewater Planning and Project Delivery Branch Head.

## *Appendix A Facility Codes*

## *Appendix B Facility Area Codes*

## *Appendix C Master Equipment Functional Designations*

## *Appendix D Equipment Number Ranges*

## *Appendix E Sample Drawings*

# The City of Winnipeg

## Water & Waste Department

# Identification Standard Appendices

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Revision: 02

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| Approved By: | *Michelle Paetkau* MP<br>Michelle Paetkau, Wastewater Planning Branch Head | March 16, 2021<br>Date |

| REVISION REGISTER | | | | | |
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| 00 | Created as a separate document for Identification Standard Appendices | 2019-12-02 | L. Harrington | E. Campbell C. Wiebe | C. Wiebe |
| 01 | Updated Facility Codes | 2020-06-02 | K.Schimke | D.Griffin | D.Griffin |
| 02 | Updated Facility Codes | 2021-03-01 | K. Schimke | M. Paetkau | M. Paetkau |
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This document is owned and maintained by the Wastewater Planning and Projects Delivery Branch of the Engineering Services Division. For questions, comments or revisions please contact the Wastewater Planning and Projects Delivery Branch Head.

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# 1 INTRODUCTION

This Water and Waste Department (WWD) Identification Standard Appendices (appendices) document is to be referenced for consistent and accurate identification for facilities. The appendices will be coordinated with the Identification Standard and document numbering standards as appropriate.

## 1.1 Document Revisions

Wastewater Planning and Project Delivery Branch (WWPPD) will issue revisions to the document on an as required basis. WWPPD will send out an email requesting review and comments by the division list below.

All proposed revisions shall be circulated to the following divisions and branches:

- Water Services Division
- Wastewater Services Division
- Solid Waste Services Division
- Engineering Division
    - Asset Management Branch
    - Design and Construction Branch
    - Drafting and Graphic Services Branch
    - Land Drainage and Flood Protection Branch
    - Wastewater Planning and Project Delivery Branch
    - Water Planning and Project Delivery Branch

# Appendix A Facility Codes

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.1 Project Facility Codes

It is the responsibility of the Project Manager to notify Drawing Control and Underground Structures (UGS) Approval Process Technologist from the Design and Graphics Branch (D&G) of any consultant or in-house projects requiring City drawings numbers during the Planning phase of a project. In the email, provide the project name, description of the project and the anticipated deliverables (drawings), facility code(s) and any applicable area codes.

### A.1.1 Creating New Facility Codes

It is the responsibility of the Project Manager to notify the WWPPD when a new facility code is required for a project. Request a new facility code by emailing WWPPD (cc. Drawing Control and UGS Approval Process Technologist from D&G) the following information:

- Project name
- Description of the project
- Proposed facility code name
- Type of facility (i.e. Collection Facility)

A review of the request will be undertaken by WWPPD in consultation with D&G and appropriate business unit (if required). WWPPD will update the Facility Codes Document and send an email with the assigned facility code to D&G and the Project Manager.

### A.1.2 Revising Existing Facility Codes

Only WWPPD can revise the WWD Facility Codes. If it is determined that a facility code needs to be revised, Project Managers should send an email to the WWPPD (cc. Drawing Control and UGS Approval Process Technologist from D&G) informing them of why the change is needed. Some examples that would warrant a revision include:

- Naming errors (need to align with WWD naming structure and asset categories)
- Duplication of facility codes
- Decommissioning of a facility
- Merging of two facilities

A review of the request will be undertaken by WWPPD in consultation with D&G and appropriate business unit (if required). If accepted, WWPPD will update the Facility Codes and send an email to D&G and the Project Manager.

### A.2 Definitions

***Future***: Facility code reserved for upcoming project.

***Spare***: Facility code available for use within the specified facility category or sub-category (i.e. ‘Sewage Treatment Facilities’).

***Unused***: Facility codes available for a new facility category.

***Discontinued***: Facility code is no longer in use and is not to be reassigned.

| Facility Code | Facility |
|---|---|
| **0001** | **General – to be used only when no other facility codes apply** |
| **0002 - 0099** | **Unused** |
| **0100 - 0109** | **Sewage Treatment Facilities** |
| 0100 | General – Sewage Treatment Facilities |
| 0101 | North End Sewage Treatment Plant (NEWPCC) |
| 0102 | South End Sewage Treatment Plant (SEWPCC) |
| 0103 | West End Sewage Treatment Plant (WEWPCC) |
| 0104-0109 | Spares |
| **0110 - 0299** | **Collections Facilities – Lift, Flood Pumping, CSO & Diversion Stations** |
| 0110 | General – Collections Facilities (Lift, Flood Pumping, CSO and Diversion Stations) |
| 0111 | DISCONTINUED (was Perimeter Road Pumping Station, now part of the WEWPCC Facility Code) |
| 0112 | Alexander Diversion Station |
| 0113 | Armstrong Diversion Station |
| 0114 | Ash Lift and Flood Pumping Stations (separate buildings on neighbouring properties) |
| 0115 | Assiniboine Flood Pumping Station |
| 0116 | Aubrey Lift and Flood Pumping Stations (separate buildings on neighbouring properties) |
| 0117 | Baltimore Lift and Flood Pumping Stations (separate buildings on neighbouring properties) |
| 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 (combined station) |
| 0124 | Clarence Lift Station |
| 0125 | Clifton Lift and Flood Pumping Stations (separate buildings) |
| 0126 | Cloutier Lift Station |
| 0127 | Cockburn Lift and Flood Pumping Station (combined station) and Diversion Chamber |
| 0128 | Colony Flood Pumping Station (formerly included in Colony Diversion Station – see 129) |
| 0129 | Colony Diversion Station |
| 0130 | Community Row Lift Station |
| 0131 | Conway Lift Station |
| 0132 | Cornish Flood Pumping Station |

| Facility Code | Facility |
|---|---|
| 0133 | Cornish Lift Station |
| 0134 | Crane Lift Station |
| 0135 | D’Arcy Lift Station |
| 0136 | Despins Lift and Flood Pumping Stations (separate buildings) |
| 0137 | Dublin Lift Station |
| 0138 | Dugald Road Lift Station |
| 0139 | Dumoulin Lift and Flood Pumping Station (combined station) and Diversion Chamber |
| 0140 | Elmhurst Lift Station |
| 0141 | Ferry Road Lift Station |
| 0142 | Galt Flood Pumping Station |
| 0143 | Grandmont Lift Station (underground) and Generator Building |
| 0144 | Hart Lift and Flood Pumping Stations (separate buildings on neighbouring properties) |
| 0145 | Hawthorne Lift and Flood Pumping Station |
| 0146 | Heritage Lift Station |
| 0147 | Holland Lift Station |
| 0148 | Jefferson Flood Pumping Station (formerly included Diversion Chamber – see 150) |
| 0149 | Jessie Lift and Flood Pumping Stations (separate buildings) |
| 0150 | Jefferson & Main Diversion Station |
| 0151 | Kilkenny Lift Station |
| 0152 | King Edward Lift Station |
| 0153 | Larchdale Lift Station |
| 0154 | Laverendrye Flood Pumping Station |
| 0155 | Linden Lift and Flood Pumping Stations (separate buildings) |
| 0156 | Louelda Lift Station |
| 0157 | Mager Drive Lift and Flood Pumping Stations (separate buildings on neighbouring properties) |
| 0158 | Manitoba Lift Station |
| 0159 | Marion Lift and Flood Pumping Stations (separate buildings on neighbouring properties) |
| 0160 | Mayfair Lift and Flood Pumping Station (combined station) |
| 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 and Diversion Stations (separate buildings) |
| 0167 | Notre Dame Lift Station |

| Facility Code | Facility |
|---|---|
| 0168 | Oak Grove Lift Station |
| 0169 | Olive Lift Station |
| 0170 | Pandora Lift Station |
| 0171 | Parklane Lift Station |
| 0172 | Parkwood Lift Station |
| 0173 | Polson Flood Pumping and Diversion Stations (separate buildings) |
| 0174 | Portsmouth Lift Station |
| 0175 | Pulberry Lift Station |
| 0176 | DISCONTINUED (was Ravelston Land Drainage Pumping Station, now part of 447) |
| 0177 | Ridgedale Lift Station |
| 0178 | Riverbend Lift Station |
| 0179 | Roland Flood Pumping Station |
| 0180 | Ryan Lift Station |
| 0181 | Selkirk Flood Pumping and Diversion Station (separate buildings) |
| 0182 | Somerville Lift Station |
| 0183 | Jefferson and Jones Diversion Chamber |
| 0184 | St. Charles Lift Station |
| 0185 | St. Johns Flood Pumping Station and Diversion Chamber |
| 0186 | St. Norbert / X-Kaley Flood Pumping Gate Chamber |
| 0187 | St. Norbert Lift Station |
| 0188 | Strathmillan Diversion Chamber |
| 0189 | Syndicate Lift and Flood Pumping Stations (separate buildings) |
| 0190 | Thibault Lift Station |
| 0191 | Trappiste Lift Station |
| 0192 | Tuxedo Lift Station |
| 0193 | Tylehurst Lift Station |
| 0194 | Westwood Lift Station |
| 0195 | Wexford Road Lift Station |
| 0196 | Willow Lift Station |
| 0197 | Windsor Park Lift Station |
| 0198 | Woodhaven Lift Station |
| 0199 | Assiniboine Park Lift Station |
| 0200 | Canora Flood Pumping Gate Chamber |
| 0201 | Crescent Drive Lift Station |
| 0202 | Ducharme High Level Site Manhole |
| 0203 | Enfield Crescent Lift Station |
| 0204 | Fort Rouge Park Flood Pumping Gate Chamber |

| Facility Code | Facility |
|---|---|
| 0205 | Irving Place Lift Station |
| 0206 | Kildare Flood Pumping Station |
| 0207 | Kildonan Park Lift Station |
| 0208 | Perimeter West Lift Station |
| 0209 | Kildonan Park 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 |
| 0214 | DISCONTINUED (was Mazenod Lift Station, now part of 5-1 St Boniface Industrial Facility Code) |
| 0215 | St. Boniface Lift Station |
| 0216 | Assiniboine Park Lift Station |
| 0217 | Barker Standby Generator Building |
| 0218 | McDermot Dry Weather Overflow Manhole/CSO |
| 0219 | Windsor Park Standby Generator Building |
| 0220 | Interceptor (Mechanical, Structural, Instrumentation and Controls only) |
| 0221 | Force main (Mechanical, Structural, Instrumentation and Controls only) |
| 0222 | Trunk (Mechanical, Structural, Instrumentation and Controls only) |
| 0223 | Sewer Monitoring |
| 0220-0299 | Spares |
| **0300 – 0399** | **Land Drainage Facilities – Pumping Sites and Outfalls** |
| 0300 | Land Drainage Facilities - General |
| 0301 | Archibald Underpass Station |
| 0302 | Bishop Grandin Underpass Station |
| 0303 | Outfalls |
| 0304 | Keewatin Underpass Station |
| 0305 | Kenaston Underpass Station |
| 0306 | Kilkenny & Rice Flood Pumping Manhole |
| 0307 | Spare |
| 0308 | McPhillips Underpass Pumping Station |
| 0309 | Metro Route 20 Underpass Pumping Station |
| 0310 | Metro Route 90 Underpass Pumping Station |
| 0311 | Transit Underpass Pumping Station (Osborne) |
| 0312-0313 | Spares |
| 0314 | St. James Underpass Pumping Station |
| 0315 | Spare |
| 0316 | Turnbull Drive Flood Pumping Manhole |

| Facility Code | Facility |
|---|---|
| 0317 | Pembina Underpass Pumping Station |
| 0318 | Pembina Wye Track Pumping Station |
| 0319 | Waverley Underpass Pumping Station |
| 0320 | Plessis Road Underpass Pumping Station |
| 0321 | Chief Peguis Underpass Pumping Station (on warranty) |
| 0322 | Beaujolais Flood Pumping Gate Chamber |
| 0323-0399 | Spares |
| **0400** | **Brady Road Landfill** |
| **0401 - 0599** | **Land Drainage – Storm Retention Basins** |
| 0401 | 1-1 Weston, south of Alexander Avenue |
| 0402 | Private Storm Retention Basins |
| 0403-0411 | Spares |
| 0412 | 2-2 St. James, off Isbister Street, north of Hamilton Avenue |
| 0413 | 2-3 St. James, south-west of Lumsden Avenue and Lake Ridge Road |
| 0414 | 2-4 St. James, north of South Lake Drive |
| 0415 | 2-5 Omand's Creek Industrial, north of Whitfield Avenue in Omand's Creek Industrial Park |
| 0416 | 2-6 The Oaks Along the Assiniboine, west pond |
| 0417 | 2-7 The Oaks Along the Assiniboine, east pond |
| 0418-0420 | Spares |
| 0421 | 3-1 Maples, south-east corner of King Edward Street and Selkirk Avenue |
| 0422 | 3-2 Maples, north-east corner of King Edward Street and Burrows Avenue |
| 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 Road |
| 0426 | 3-6 Maples, north of Templeton Avenue and west of McPhillips Street |
| 0427 | Spare |
| 0428 | 3-8 Maples, east of Keewatin Street and south of Adsum Drive |
| 0429 | 3-9 Maples, Foxwarren Drive, west of Ritchie Street |
| 0430 | 3-10 Amber Trails, west of Amber Trail and Ambergate Drive |
| 0431 | 3-11 North Inkster Industrial, east of Meridian Drive and Inksbrook Drive |
| 0432 | 3-12 North Inkster Industrial, east of Meridian Drive and north of Commercial Avenue |
| 0433 | 3-13 Amber Trails, east of Strasbourg Drive and south of Thorn Drive |
| 0434 | 3-14 Amber Trails, west of Massalia Drive |
| 0435 | 3-15 Castlebury Meadows, south-west of Jefferson Avenue and King Edward Street |
| 0436 | 3-16 Waterford Green, south of Jefferson Avenue and east of Brooksmere Trail |

| Facility Code | Facility |
|---|---|
| 0437 | 3-17 Waterford Green, north of Commonwealth Path and east of Brooksmere Trail |
| 0438 | 3-18 Aurora – North Point Village, south of North Point Boulevard, between Atlas Crescent |
| 0439 | 3-19 Amber Gates, north of Templeton Avenue, between Cartesian Gate and Tennant Gate |
| 0440 | 3-20 North Inkster Industrial, south of Haggart Avenue and west of King Edward Street |
| 0441 | Spare |
| 0442 | 4-2 East Kildonan, off Gateway Road north, of Springfield Road (Bunn's Creek) |
| 0443 | 4-3 Transcona, Cordite Ditch |
| 0444 | 4-4 Kilcona Park, north-east Park Recreation Area (Harbourview Complex) |
| 0445 | 4-5 Transcona, north-west corner of Devonshire Drive and Clouston Drive |
| 0446 | 4-6 Transcona, south-east of Devonshire Drive and Kildonan Meadow Drive |
| 0447 | 4-7 Transcona, Deep Pond, south-west Ravelston Avenue |
| 0448 | 4-8 Kilcona Park, north-east corner of Lagimodiere Boulevard and Springfield Road |
| 0449 | 4-9 Harbourview South, south of McMahon Place off McLellan Drive |
| 0450 | 4-10 East Kildonan, north of Ragsdale between East Spring and West Spring |
| 0451 | 4-11 Eaglemere, south of Eaglemere Drive |
| 0452 | 4-12 East Elmwood, north-west of Lagimodiere Boulevard and Callsbeck Avenue |
| 0453 | Spare |
| 0454 | 4-14 Arrowwood, south of Headmaster Row and west of Mitchelson Way |
| 0455 | 4-15 Harbourview South, east of Lagimodiere Boulevard and north of Concordia Avenue |
| 0456 | 4-16 Devonshire Village, south of Cal Gardner Drive and east of Peguis Street |
| 0457 | Spare |
| 0458 | 4-20 Crocus Meadows, north-west corner of Peguis Street and Ravelston Avenue West |
| 0459 | 4-21 Starlight, north of El Tassi Drive and west of Fiorentino Street |
| 0460 | 4-22 Devonshire Park, south of Devonshire Drive West, west of Sheilagh Ball Cove |
| 0461 | 5-1 St Boniface Industrial, west of Beghin Avenue at Paquin Road |
| 0462 | 5-2 St Boniface Industrial, east of Paquin Road |
| 0463 | 5-3 St Boniface Industrial, south of Camiel Sys Street, east of Ray Marius Road |
| 0464 | 5-38 Waterside Estates, west of Plessis Road south of Dugald Road |
| 0465 | 5-5 Southdale, north-east corner of Lakewood Boulevard and Edgewater Drive |
| 0466 | 5-6 Southdale, west of Beaverhill Boulevard and north of Edgewater Drive |
| 0467 | 5-7 Southdale, north-west corner of Lakewood Boulevard and Beaverhill Boulevard |

| Facility Code | Facility |
|---|---|
| 0468 | 5-8 Southdale, south of Edgewater Drive between Sweetwater Bay and Beaverhill Boulevard |
| 0469 | 5-9 Southdale, east corner of Shamrock Drive and Newcroft Road |
| 0470 | 5-10 Southdale, south of Willowlake Crescent at Willow Point Road |
| 0471 | 5-11 North St Vital, north of Bishop Grandin Boulevard at Kearney Street |
| 0472 | 5-12 North St Vital, north of Bishop Grandin Boulevard at Glen Meadow Street |
| 0473 | 5-13 North St Vital, north of Bishop Grandin Boulevard at River Road |
| 0474 | 5-14 St Boniface Industrial, north of Dynamic Machine (1417 Dugald Road) |
| 0475 | 5-15 Island Lakes, south of Island Shore Boulevard |
| 0476 | 5-16 St Vital, south-west of Burland Avenue and Healy Crescent |
| 0477 | 5-17 St Vital, south-east of Burland Avenue and Westbourne Crescent |
| 0478 | 5-18 St Vital, east of Dakota Street and south of John Forsythe Avenue |
| 0479 | 5-19 Island Lakes, south of Island Lakes Drive |
| 0480 | 5-20 Island Lakes, north-west of Island Lakes Drive and De la Seigneurie Boulevard |
| 0481 | 5-21 Southland Park, north-east of Royal Mint Drive |
| 0482 | 5-22 Royalwood, south-west corner of Shorehill Drive and Aubin Drive |
| 0483 | 5-23 South Transcona, north-west of St. Boniface Road and Murdock Road |
| 0484 | 5-24 Royalwood, along Westwater Drive |
| 0485 | 5-25 Royalwood, east of Shorehill Drive and Bridgetown Drive |
| 0486 | 5-26 Buhler Recreational Park, south of the Parking Lot |
| 0487 | 5-27 Buhler Recreational Park, north of Lake Shirley |
| 0488 | 5-28 Sage Creek, north of Warde Avenue and east of Lagimodiere Boulevard |
| 0489 | 5-29 Sage Creek, west of Des Hivernants Boulevard and north of Woodsage Crescent |
| 0490 | 5-30 Sage Creek, north of Tallgrass Crescent and east of Des Hivernants Boulevard |
| 0491 | 5-31 Sage Creek, east of Hydro ROW, north of Red Lily Road and south of Blue Sun Drive |
| 0492 | 5-32 Sage Creek, north of Warde, west of Blue Sun Drive and east of Red Lily Road |
| 0493 | 5-33 Sage Creek, east of Lagimodiere Boulevard and west of Burning Glass Road |
| 0494 | 5-34 Sage Creek, north of David Friesen Road between Des Hivernants Boulevard and Burning Glass Road |
| 0495 | 5-35 Sage Creek, east of Des Hivernants Boulevard and west of Hydro ROW |
| 0496 | 5-36 Sage Creek, west of Wild Iris Walk and North of Prairie Smoke Drive |
| 0497 | 5-37 Sage Creek, east of Wild Iris Walk and South of Vireo Lane |
| 0498 | 5-39 Sage Creek, south of Warde Avenue and east of Robert Bockstael Drive |
| 0499 | 5-40 Sage Creek, south of Sundog Drive |

| Facility Code | Facility |
|---|---|
| 0500 | 5-41 Sage Creek, east of Ed Turner Drive and south of West Plains Drive |
| 0501 | 5-42 Bonavista, west of Evelyne Reese Boulevard and north of Bow Water Drive |
| 0502 | 5-43 Bonavista, east of Evelyne Reese Boulevard and south of Bonaventure Drive East |
| 0503-0510 | Spares |
| 0511 | 6-1 Assiniboine Forest, south of Grant Avenue and east of Chalfont Road |
| 0512 | Spare |
| 0513 | Spare |
| 0514 | 6-4 West Fort Garry Business, Lot 16 Drain west of Waverley Street |
| 0515 | 6-5 Fort Garry Industrial, ditch along Bishop Grandin Boulevard |
| 0516 | 6-6 Waverley Heights, north of Chancellor Drive between Swan Lake Bay and Lake Grove Bay |
| 0517 | 6-7 Waverley Heights, along Lake Lindero Road |
| 0518 | 6-8 Waverley Heights, south of Markham Road at Forest Lake Drive |
| 0519 | 6-9 Waverley Heights, north of Markham Road and west of Forest Lake Drive |
| 0520 | 6-10 Fort Richmond, north of Dalhousie Drive and east of Pembina Highway |
| 0521 | 6-11 Fort Richmond, south of Dalhousie Drive and east of Pembina Highway |
| 0522 | 6-12 St Norbert, north of Grandmont Boulevard and west of Nolin Avenue |
| 0523 | 6-13 St Norbert, south of Grandmont Boulevard and west of Delorme Bay |
| 0524 | 6-14 West Fort Garry Business, east of Kenaston Boulevard and south of Scurfield Boulevard |
| 0525 | 6-15 Lindenwoods, west of Shorecrest Drive |
| 0526 | 6-16 Richmond West, Point West Drive |
| 0527 | 6-17 Whyte Ridge, south-west of Scurfield Boulevard and Columbia Drive |
| 0528 | 6-18 Lindenwoods, north of Shoreline Drive and south of Queens Park Crescent |
| 0529 | 6-19 Tuxedo West, south of West Taylor Drive and west of Dumbarton Boulevard |
| 0530 | 6-20 Whyte Ridge, west of Scurfield Drive and south of Vanderbilt Drive |
| 0531 | 6-21 St Norbert, south of Bellemer Drive (Grandmont Park) |
| 0532 | 6-22 Lindenwoods, north of Wilkes Avenue and west of Waverly Street |
| 0533 | 6-23 Tuxedo Industrial, west of Kenaston Boulevard |
| 0534 | 6-24 Lindenwoods, east of Lindenwoods Drive West |
| 0535 | 6-25 Linden Ridge, east of Dovercourt Drive |
| 0536-0538 | Spares |
| 0539 | 6-29 Fairfield Park, south of Lee Boulevard and west of Raphael Street |
| 0540 | 6-30 Kenaston Common, north of Lindenwood Drive East and west of Kenaston Boulevard |
| 0541 | 6-31 Marlton, east of Oakdale Drive between Roblin Boulevard and Grant Avenue |

| Facility Code | Facility |
|---|---|
| 0542 | 6-32 Waverley West (South Pointe), west of Autumnview Drive and east of Cypress Ridge Road |
| 0543 | 6-33 Waverley West (South Pointe), west of Yorkvalley Way and north of Kirkbridge Drive |
| 0544 | 6-34 Waverley West (South Pointe), south of Kirkbridge Drive and west of Waterstone Drive |
| 0545 | 6-35 Waverley West (South Pointe), south of Northern Lights Drive and north of Turnstone Terrace |
| 0546 | 6-36 Waverley West (Bridgwater Forest), south of Bridgeland Drive and east of Prominence Point |
| 0547 | 6-37 Waverley West (Bridgwater Forest), west of Highland Creek Road and north of Hunterbrook Road |
| 0548 | 6-38 Waverley West (Bridgwater Forest), west of Park Valley Road and south of North Town Road |
| 0549 | Spare |
| 0550 | 6-40 Waverley West (South Pointe), west of Waverly Street and east of Stan Baile Drive (Not accepted by City, Naturalized, Started Warranty) |
| 0551 | 4-18 Bridgewood Estates, east of Edward Schreyer opposite Concordia Avenue East |
| 0552 | 6-41 Waverley West (Bridgwater Centre), west of Cooper's Town Road |
| 0553 | 6-42 Waverley West (Bridgwater Centre), north-east corner of Park East Drive and Kenaston Boulevard |
| 0554 | 6-43 Waverley West (Bridgwater Centre), west of Jacob’s Creek Road |
| 0555 | 6-44 Waverley West (Bridgwater Centre), east of Jacob's Creek Road |
| 0556 | 6-45 Waverley West (Bridgwater Forest), south-east corner North Town Road and Hill Grove Point |
| 0557 | 6-46 Waverley West (Bridgwater Lakes), south of Montpellier Point |
| 0558 | 6-47 Waverley West (Bridgwater Lakes), south of Clear Spring Road |
| 0559 | 6-48 Waverley West (Bridgwater Lakes), north-west of Bluemeadow Road and Water Bend Road |
| 0560 | 6-49 Waverley West (Bridgwater Lakes), north-west of Bridge Lake Drive and Lake Bend Road |
| 0561 | 6-50 Waverley West (South Pointe), south of Canvasback Cove |
| 0562 | 6-51 Waverley West (South Pointe), south-west of Northern Light Drive and Stan Bailie Drive |
| 0563 | Spare |
| 0564 | 6-54 Waverley West (Bridgwater Trails), north-west of Rose Lake Court |
| 0565 | 6-55 Waverley West (Bridgwater Trails), north-east of Rose Lake Court |
| 0566 | 6-56 Waverley West (Bridgwater Trails), south-west of Rose Lake Court |
| 0567 | 6-57 Waverley West (Bridgwater Trails), south-east of Rose Lake Court |
| 0568 | 6-58 Waverley West (Bridgwater Trails), east of Eaglewood Drive between Valley Brook Road and Bridge Lake Drive |

| Facility Code | Facility |
|---|---|
| 0569 | 6-59 Waverley West (Bridgwater Trails), east of Landover Drive between Willow Creek Road and Rowntree Avenue |
| 0570 | 6-60 Waverley West (Bridgwater Trails), south of Appleford Gate and west of Landover Drive |
| 0571 | 6-61 Waverley West (Bridgwater Trails), south-east of Wildflower Road and north of Silver Creek Road |
| 0572 | 6-62 South Pointe Phase 2, west of Kenaston Boulevard and east of Ken Oblik Drive |
| 0573 | 6-63 South Pointe Phase 2, south of Waverly Street and west of Ken Oblik Drive |
| 0574 | 6-64 Scotswood Meadows, south-west of the intersection at ScotsWood Drive South and Rannock Avenue |
| 0575 | 6-65 Ridgewood West, east of Peregrine Point and south of McKellar Drive |
| 0576 | 6-66 Ridgewood West, north of Couture Crescent and east of Cassowary Lane |
| 0577 | 6-68 Bishop Grandin Crossing, north of Ballantrae Drive and east of New Market Boulevard |
| 0578 | 6-69 SouthPointe Phase 2, between Berry Hill Road and Hawkridge Road |
| 0579 | 6-70 South Pointe Phase 2, south of Berry Hill Road and north of Granite Grove Road |
| 0580-0599 | Spares |
| **0600 - 0799** | **Water System Facilities** |
| 0600 | Shoal Lake Aqueduct Intake Facility (Yard and M97.51 Backbone Repeater) Falcon River Diversion |
| 0601 | Winnipeg Drinking Water Treatment Plant (Yard and M12.87 Backbone Repeater) |
| 0602-0619 | Spares |
| 0620 | DISCONTINUED (was Deacon Booster Pumping Station, now part of the Winnipeg Drinking Water Treatment Plant Facility Code) |
| 0621-0629 | Spares |
| 0630 | MacLean Regional Pumping Station, MacLean Reservoir |
| 0631-0639 | Spares |
| 0640 | McPhillips Regional Pumping Station,<br>McPhillips Reservoir and M01.00 Backbone Repeater<br>McPhillips Control Centre<br>Collections Building |
| 0641-0649 | Spares |
| 0650 | Hurst Regional Water Pumping Station, Wilkes Reservoir |
| | |
| 0651-0659 | Spares |
| 0660 | Tache Booster Pumping Station, Tache Surge Tower |
| 0661-0700 | Spares |

| Facility Code | Facility |
|---|---|
| 0701 | DISCONTINUED (was General Shoal Lake Aqueduct & GWWD, now part of the Shoal Lake Aqueduct and Greater Winnipeg Water District (GWWD) Railway Facility Codes) |
| 0702 | St. Boniface Yards (552 and 598 Plinguet St) |
| 0703-706 | Spares |
| 0707 | Ross (Yard and M39.00 Backbone Repeater) |
| 0708-0710 | Spares |
| 0711 | Hadashville (Yard and Backbone Repeater) |
| 0712-0750 | Spares |
| 0751 | Shoal Lake Aqueduct (includes Branch 1 Aqueduct) |
| 0752 | Branch 2 Aqueduct |
| 0753 | Aqueduct Interconnection |
| 0754 | Greater Winnipeg Water District (GWWD) Railway |
| 0755-0797 | Spares |
| 0798 | Feeder Mains and Large Diameter Water Mains |
| 0799 | General Water Facilities |
| **0800 - 0849** | **Public Water Outlets and Remote Pressure Monitoring Locations** |
| 0800 | General Public Water Outlets and Pressure Monitoring |
| 0801 | Public Water Outlet – 1539 Waverley Street |
| 0802 | Public Water Outlet– Portage Avenue at Perimeter Highway<br>(McCarthy St. and Oxbow Bend Road) |
| 0803-0811 | Spares |
| 0812 | Pressure Monitoring Location - Gateway - Gateway Road and Springfield Road |
| 0813 | Spare |
| 0814 | Pressure Monitoring Location - Brookside - Brookside Boulevard and Inkster Boulevard |
| 0815 | Spare |
| 0816 | Pressure Monitoring Location - John Black - John Black Avenue and Main Street |
| 0817 | Spare |
| 0818 | Pressure Monitoring Location - Smugglers Cove - Lagimodiere Boulevard and Smugglers Cove |
| 0819 | Spare |
| 0820 | Pressure Monitoring Location - Charing Cross - Paddington Road and Charing Cross Crescent |
| 0821 | Spare |
| 0822 | Pressure Monitoring Location - University - Pembina Highway and Chancellor Matheson Road |
| 0823 | Spare |
| 0824 | Pressure Monitoring Location - Devonshire - Plessis Road and Devonshire Drive |

| Facility Code | Facility |
|---|---|
| 0825 | Spare |
| 0826 | Pressure Monitoring Location – Redonda - Redonda Street and Kildare Avenue |
| 0827 | Spare |
| 0828 | Pressure Monitoring Location - Rouge Road - Rouge Road and Assiniboine Ave |
| 0829 | Spare |
| 0830 | Pressure Monitoring Location - St. Norbert - Rue Des Trappistes and Villeneuve Boulevard |
| 0831 | Spare |
| 0832 | Pressure Monitoring Location - Sargent - Sargent Avenue and St. James Street |
| 0833-0849 | Spares |
| **0850 - 0899** | **Solid Waste Facilities, Excluding Brady Road Landfill** |
| 0850 | General Solid Waste Facilities |
| 0851 | Pacific Avenue 4R Depot |
| 0852 | Panet Road 4R Depot |
| 0853 | Closed Landfills |
| N/A | Brady Road Landfill (See FC 400) |
| 0854-0899 | Spares |
| **0900 - 0999** | **Unused - Spares** |
| | |

# Appendix B Facility Area Codes

### Area Codes – Shoal Lake Aqueduct Intake Facility

| Area Code | Description |
|---|---|
| A | General or area code 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 House |
| U | SCADA |

### Area Codes – Shoal Lake Aqueduct

| Area Code | Description |
|---|---|
| A | General or area code is not applicable (SCADA) |
| B | Backbone Repeater |
| C | Boathouse |
| D | Remote Terminal Units |
| M | Manholes |
| N | Underdrains |
| O | Overflow |
| P | Shoal Lake Aqueduct (Pipe) |
| Q | Branch 1 Aqueduct (Pipe) |
| R | G.W.W.D. Railway |
| S | Drainage Siphon |
| T | Communication Tower |
| U | Road Crossing |
| V | Venturi |
| W | Valve Chamber |

**Area Codes – Winnipeg Drinking Water Treatment Plant**

| Area Code | Description |
|---|---|
| A | Administration |
| B | Main Treatment Plant Building |
| C | Chemical Feed Systems (Polymer, SBS, Hydrogen Peroxide) |
| D | Deacon Booster Pumping Station<br>(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) / Force Main |
| M | General Plant Services / Miscellaneous<br>(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 | Treated Water Storage (Clearwell) |
| U | Instrumentation and Control (SCADA) |
| V | Civil Maintenance and Aqueduct Storage Building |
| W | *Future* |
| X | Pilot Plant |
| Y | Yard Piping and Valve Chamber |
| Z | Deacon Chemical Feed Facility |

*Note: The current application of area codes does not meet the intent of this standard in that it is not based upon a physical location. For example, the H area code is for all plant utilities across the entire building.*

**Area Codes – Regional Water Pumping Stations**

| Area Code | Description |
|---|---|
| A | General or area code is not applicable |
| B | Collections Building (McPhillips only) |
| C | Chlorine Building / Area |
| M | Main Pumping Station Building |
| P | SCADA, PLC, RTU |
| R | Reservoir and Ancillary Buildings |
| S | Control Centre Building (McPhillips Only) |
| Y | Yard Piping and Valve Chambers/ Drain Building |

**Area Codes – Feeder Mains and Large Diameter Water Mains**

| Area Code | Description |
|---|---|
| A | General or area code is not applicable |
| B | Valve Chambers |
| C | Railroad Crossings |
| D | Road Crossings |
| E | River Crossings |
| F | Feeder Mains |
| W | Large Diameter Water Mains |

**Area Codes – St. Boniface Yards (552 and 598 Plinguet St)**

| Area Code | Description |
|---|---|
| A | General or area code is not applicable |
| C | Civil Maintenance Buildings |
| G | G.W.W.D. Railway Station (Building 1) |
| M | Meter Shop (Building 15) |
| N | 552 Plinguet - North Building (Building 3) |
| O | Storage Buildings |
| P | 598 Plinguet - Railway Shop (Building 2) |
| R | Rail Car Storage (Buildings 19 & 20) |
| S | 552 Plinguet - South Building – Shop (Building 4) |
| T | Track #9 Depot |
| W | St. Boniface Water Tower (Building 14) |
| Y | Yard Piping and Valve Chambers |

**Area Codes – Land Drainage**

| **Area Code** | **Description** |
| --- | --- |
| A | General or area code is not applicable |
| B | Storm Retention Basin (SRB) |
| F | Flood Pumping Manhole |
| G | Gate Chambers |
| L | Land Drainage Pumping Station |
| O | Outfalls |
| U | Underpass Pumping Station |
| W | Deep Well Pump |

**Area Codes – NEWPCC**

| **Area Code** | **Description** |
| --- | --- |
| A | General or area code is not applicable |
| B | Boilers |
| C | Centrate Treatment |
| D | Digesters |
| E | Electrical Building and Substation |
| F | Phosphorous Removal Facility |
| G | Pre-Aeration and Grit Removal |
| H | *HOLD – Potentially reserve for Headworks area code. Decision to be made under the sewage treatment upgrade program.* |
| 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 |

*Notes:*

*1. The NEWPCC area codes will be updated as part of the NEWPCC Upgrade project.*

**Area Codes – SEWPCC**

| Area Code | Description |
|---|---|
| A | General or area code is not applicable |
| B | Service Building (includes Boilers, Storage Building and Standby Building) |
| C | Chemical / Electrical Building |
| D | Fermenters / Sludge Thickeners |
| G | Headworks (Pump and Screen building, Grit Building) |
| H | Sludge Gas – Thermal Oxidizer |
| K | High-Rate Clarification Building |
| M | Administration Building |
| P | Primary Clarifiers |
| R | Bioreactors / Blower Building |
| S | Secondary Clarifiers |
| T | Biofilter / Odour Control |
| U | UV Disinfection Building, Outfall |
| Y | Yard / Electrical Substation |

**Area Codes – WEWPCC**

| Area Code | Description |
| --- | --- |
| A | General or area code is not applicable |
| F | Primary Sludge Fermenters |
| G | DISCONTINUED - Formerly Headworks |
| 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<br>HOLD – Possible re-allocation for future UV Disinfection |
| V | HOLD – Possible re-allocation as the Utility Building.<br>(See Note 1) |
| Y | *HOLD – Possible use for Yard. Decision to be made under the sewage treatment upgrade program.* |
| Z | Ponds, Effluent and Outfall |

*Notes:*

1. *Some equipment in the WEWPCC Utility Building has already been re-identified as V.*

**Area Codes – Wastewater Collections**

| Area Code | Description |
| --- | --- |
| A | General or area code is not applicable |
| F | Flood Pumping Stations |
| L | Wastewater Lift Stations |
| S | Sewer |

## Area Codes – Solid Waste BRRMF

| Area Code | Description |
|---|---|
| A | General or area code is not applicable |
| B | Biosolids and LYW Composting |
| C | Administration Building |
| R | Brady 4R Winnipeg Depot |

## Area Codes – Solid Waste

| Area Code | Description |
|---|---|
| A | General or area code is not applicable |
| C | Closed Landfills |
| R | 4R Depot |

# Appendix C Master Equipment Functional Designations

| Functional Designation | Description | Type | Notes |
|---|---|---|---|
| ACP | Access Control Panel | Security | |
| ACU | Air Conditioning Unit | Mechanical | |
| AD | Air Dryer | Mechanical | |
| 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 | . |
| BDD | Backdraft Damper | Mechanical | |
| BFP | Back Flow Preventer | Mechanical | |
| BLR | Boiler | Mechanical | |
| ~~BS~~ | ~~Bar Screen~~ | ~~Mechanical~~ | Use SCR |
| BV | Balancing Valve | Mechanical | Manual mechanical balancing valve (not typically adjusted by operations). |
| BVA | Balancing Valve Automatic | Mechanical | Automatic mechanical balancing valve. |
| 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 | Condenser | Mechanical | |
| CE | Centrifuge | Mechanical | |
| CHLR | Chiller | Mechanical | |

| Functional Designation | Description | Type | Notes |
|---|---|---|---|
| CM | Clarifier Mechanism | Mechanical | |
| CMP | Compressor | Mechanical | |
| CN | Network Cable | Communication | |
| CNP | Network Cable - Patch | Communication | |
| CNV | Conveyor | Mechanical | Includes skimmers |
| CON | Contactor | Electrical | |
| CP | Control Panel | Electrical | |
| CP | Control Panel | Automation | |
| 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 | |
| CYC | Cyclone | Mechanical | |
| DCS | Distributed Control System | Automation | |
| DP | Distribution Panel | Electrical | |
| DS | Disconnect Switch (non-fusible) | Electrical | |
| EDP | Electrical Device Panel | Electrical | Use for metering panels, protection panels and other Miscellaneous electrical panels. |
| EDU | Eductor | Mechanical | |
| 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 | |

| Functional Designation | Description | Type | Notes |
|---|---|---|---|
| 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 | |
| GR | Grille / Louvre – General | Mechanical | . |
| GRD | Grille – Diffuser | Mechanical | . |
| 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 | |
| INV | Inverter | Electrical | |
| ISB | Intrinsic Safety Barrier | Automation | Typically only a subcomponent. |
| JB | Junction Box | Electrical | |
| JBA | Junction Box (Automation) | Automation | |
| JBN | Junction Box - Network | Communication | |
| K | Interlocking Key (Kirk Key) | Electrical | |
| LC | Lighting Contactor | Electrical | A lighting control panelboard would be identified as a PNL. |

| Functional Designation | Description | Type | Notes |
|---|---|---|---|
| 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 | |
| ND | Network Device | Communication | Utilize for general devices not otherwise in list. Example: network terminators |
| NFW | Network Firewall | Communication | |
| 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 | |
| NRP | Network Repeater | Communication | |
| NRT | Network Router | Communication | |
| NSP | Network Segment Protector | Communication | Typically used for PROFIBUS PA |
| NSW | Network Switch, Ethernet | Communication | |
| NT | Network Terminator | Communication | |
| OD | Overhead Door | Mechanical | |
| P | Pump | Mechanical | |
| PB | Pull Box | Electrical | |
| PCV | Pressure Control Valve (Pressure Regulator) | Mechanical | |
| PFC | Power Factor Correction Unit | Electrical | Bank of capacitors. May contain reactors. |

| Functional Designation | Description | Type | Notes |
| --- | --- | --- | --- |
| 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 |
| PSV | Pressure Safety/Relief Valve | Mechanical | |
| R | Reactor (various processes) | Mechanical | |
| RCFR | Rectifier | Electrical | |
| RCPT | Receptacle | Electrical | |
| RCTR | Reactor | Electrical | |
| RDT | Rotary Drum Thickener | Mechanical | |
| RES | Reservoir | Mechanical | Large water containment structure. |
| RIO | Remote I/O | Automation | |
| RLY | Protection Relay | Electrical | |
| RTU | Remote Terminal Unit | Automation | |
| S | Skid Package | Mechanical | |
| SA | Sampler | Mechanical | |
| SCBR | Scrubber | Mechanical | |
| SCP | Security Control Panel | Security | |
| SCR | Screen | Mechanical | Utilized for screening systems such as bar screens and perforated plate screens. |
| SD | Smoke Damper | Mechanical | Utilize same equipment number as air handler. |
| SF | Supply Fan | Mechanical | |
| SGR | Switchgear | Electrical | |
| SL | Stop Logs | Mechanical | |
| SLG | Sluice Gate | Mechanical | May only be utilized within existing facilities where the use of the SLG identifier is well established. The designation may not to be utilized for new or upgraded WSTP facilities. Identify as a valve (HV, XV, FV, etc.). |
| SPL | Splitter | Electrical | |
| SS | Soft Starter | Electrical | |

| Functional Designation | Description | Type | Notes |
|---|---|---|---|
| STR | Strainer | Mechanical | See Section 5.2 |
| SVM | Security Video Monitor | Security | |
| SVR | Security Video Recorder | Security | |
| SW | Switch | Electrical | |
| TB | Terminal Block | Automation | Subcomponent Only |
| 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 / Electrical / Automation | 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 | |
| WCP | Washer / Compactor | Mechanical | |
| WGB | Waste Gas Burner | Mechanical | |
| XFMR | Transformer | Electrical | |

# Appendix D Equipment Number Ranges

**Equipment Number Ranges – Shoal Lake Intake Facility**

| Area Code | Range | Description |
|---|---|---|
| All Areas | 001 - 049 | Major Pumping |
| | 050 - 099 | Future |
| | 100 – 499 | Process Equipment |
| | 500 – 599 | Misc. Building Equipment – Air Compressors, Sump Pumps, Fuel Systems, 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**

| Area Code | Range | Description |
|---|---|---|
| All Areas | TBD | Needs to be developed. |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |

**Equipment Number Ranges – Winnipeg Drinking Water Treatment Plant**

| Area Code | 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 |

| Area Code | Range | Description |
|---|---|---|
| X – Pilot Plant | 001 - 999 | Process |
| Y – Yard Piping and Valve Chambers | 001 - 099 | Surge Towers |
| | 100 - 199 | Yard Piping |
| | 200 - 299 | Yard Lighting |
| Z – Deacon Chemical Feed Facility | 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**

| Area Code | Range | Description |
|---|---|---|
| All Area Codes | 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**

| Area Code | 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 – SEWPCC and WEWPCC Wastewater Treatment Facilities**

| Area Code | Range | Process Code | Description |
|---|---|---|---|
| All Area Codes | 001 - 099 | 0 | Area Specific Processes |
| | 100 – 199 | 1 | Area Specific Processes |
| | 200 – 299 | 2 | Area Specific Processes |
| | 300 – 399 | 3 | Area Specific Processes |
| | 400 – 499 | 4 | Area Specific Processes |
| | 500 – 599 | 5 | Misc. Building Equipment – Air Compressors, Backflow Preventer, etc. (May be allocated for process as required) |
| | 600 - 699 | 6 | HVAC Equipment |
| | 700 - 799 | 7 | Electrical Equipment |
| | 800 – 899 | 8 | Automation Equipment |
| | 900 – 999 | 9 | Misc., including communication and security |

*Note: Refer to the IMS for further definition of Equipment Number ranges and Process Codes within the Wastewater Treatment Facilities.*

**Equipment Number Ranges – NEWPCC Wastewater Treatment Facility**

| Area Code | Range | Process Code | Description |
|---|---|---|---|
| All Area Codes | 0001 - 0999 | 0 | Area Specific Processes |
| | 1000 – 1999 | 1 | Area Specific Processes |
| | 2000 – 2999 | 2 | Area Specific Processes |
| | 3000 – 3999 | 3 | Area Specific Processes |
| | 4000 – 4999 | 4 | Area Specific Processes |
| | 5000 – 5999 | 5 | Misc. Building Equipment – Air Compressors, Backflow Preventer, etc.<br>(May be allocated for process as required) |
| | 6000 – 6999 | 6 | HVAC Equipment |
| | 7000 – 7999 | 7 | Electrical Equipment |
| | 8000 – 8999 | 8 | Automation Equipment |
| | 9000 – 9999 | 9 | Misc.., including communication and security |

*Note: Refer to the IMS for further definition of Equipment Number ranges and Process Codes within the Wastewater Treatment Facilities.*

# 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 |

| City Drawing Number | Sheet | Rev | Project / Area | TITLE |
|---|---|---|---|---|
| 1-0630C-SK01 | 001 | 00 | | PROCESS & INSTRUMENTATION DIAGRAM, CHLORINE CYLINDER SHUTOFF VALVES |
| 1-0630C-SK02 | 001 | 00 | | PROCESS & INSTRUMENTATION DIAGRAM, CHLORINATION 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, MISC.ELLANEOUS |
| 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 FEEDERMAINS |

# The City of Winnipeg

## Water & Waste Department

# Wastewater Treatment Facilities Automation Design Guide

Document Code:

Revision: 03

| | | |
|---|---|---|
| Approved By: | Colin Javra, P.Eng<br>Project Director – Winnipeg Sewage Treatment Program | March 7, 2023<br>Date |

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# TABLE OF CONTENTS

# 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:

- All new designs, not related to an existing facility, are expected to be subject to the utilization of this guideline.
- 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 based on input from any stake holder.
- 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 based on input from any stake holder.

Where a requirement is indicated with the word "should", the designer may deviate from the indicated requirement provided that:

- the rationale for deviation is reasonable and logical from a design perspective;

- the chosen design solution provides a solution that equivalently meets the intent; and
- The City is in no way disadvantaged by the alternate design solution
- The developer submits documentation detailing deviation to the City for approval.

The model numbers provided within this document are indicative of preferred equipment with features required by the City (at the time of writing). In addition, the City is/would be likely to carry stock spares parts of and/or replacement units of the indicated models. The indicated model number should be utilized where these models are still current, actively marketed and fully meet the project requirements without any disadvantage to the City. Where a newer/replacement model is available that satisfies the minimum requirements, and has additional features that would benefit the City, the newer models shall be utilized in place of current models, as required to meet the project requirements,

## 1.3 Acronyms and Abbreviations

| | |
|---|---|
| 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) |
| EDDL | Electronic Device Description Language - IEC 61804 |
| EMT | Electrical Metallic Tubing |
| FAT | Factory Acceptance Test |
| GSD | General Station Description (description of the PROFIBUS DP/PA or PROFINET device) |
| JB | Junction Box |
| HMI | Human Machine Interface |
| HOA | Hand - Off - Auto (switch) |
| HOR | Hand - Off - Remote (switch) |
| HP, hp | Horsepower |

| | |
|---|---|
| HSBY | Hot Standby |
| 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) |
| RFI | Request for Information |
| RIO | Remote I/O |
| RRF | Risk Reduction Factor |
| RSTP | Rapid Spanning Tree Protocol |
| RTU | Remote Terminal Unit |
| SAT | Site Acceptance Test |
| SCCR | Short Circuit Current Rating |

| | |
|---|---|
| SIS | Safety Instrumented System |
| SIF | Safety Instrumented Function |
| SIFT | System Integrated Functional Test |
| SIL | Safety Integrity Level |
| SIT | Site Integrated Test |
| SP | Setpoint |
| STEL | Short Term Exposure Limit |
| TLV | Threshold Limit Value |
| TWA | Time Weighted Average |
| 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 |

## 1.4 Definitions

| | |
|---|---|
| As-Built Documents | Drawings and other design documents that represent the final state of the project, as constructed and commissioned, and are not authenticated by a professional engineer. |
| Automation Room | A room primarily containing automation equipment, such as PLCs and control panels, but not typically occupied by personnel for operations functions. |
| Building Mechanical | All mechanical systems associated with buildings and infrastructure, but not including process mechanical systems. Ventilation associated with odour control systems, but not necessarily the odour treatment system itself, should be considered as part of the Building Mechanical system. |
| Codes | As defined in Section 2.1.3 |
| Commissioning Authority | The person or firm responsible for the delivery of the commissioning process. |
| Contractor | The entity responsible for constructing the design. In a design-build procurement methodology, this is the design-builder. |
| Control Room | A room containing PCS operator workstations and other operator systems for monitoring and controlling the facility. |

| | |
|---|---|
| Design Team | The entity responsible for providing the detailed design of a project. In a design-bid-bid procurement methodology, this is typically the consultant. In a design-build procurement methodology, this is the design-builder. |
| Electrical Room | A room this is primarily designated to contain electrical equipment, including switchgear, MCCs and panelboards. |
| Engineer of Record | The professional engineer ultimately responsible for the design registered in the Province of Manitoba. |
| Hazardous Location | An area where flammable liquids, gases, vapors or combustible dusts may exist in sufficient quantities to produce an explosion or fire. |
| Non-Process Area | Any area or location either within or outside of a building that is not a Process Area. |
| Process Area | Any area or location either within or outside of a building that contains piping, equipment, or any other asset that contains or handles a process fluid or material, including chemicals. Within a building, a single room or space cannot be divided into both a Process Area and a Non-Process Area. |
| Server Room | A room that is primarily designated for containing computer and networking equipment. |
| System Integrator | The entity responsible to design/develop, install, test and commission all aspects of a fully functional Process Control System based on the Automation Design Guide requirements and any/all additional requirements defined by contract. |

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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 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. Tag name 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 |
| 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 codes and bylaws, together with any bulletins or addenda thereto, shall be referenced when performing automation designs for the City of Winnipeg.

1. Manitoba Electrical Code 76/2018
2. Winnipeg Electrical Bylaw 72/2022

## 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.

# 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 new HMI and historian systems.

The City underwent a standardization process to standardize on the make and model of new Process control system (PCS) equipment (including PLCs, HMI software, HMI hardware, historian 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

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) and S+ 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 cord sets.

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 a PLC based PCS.

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 PCS 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 PCS installations.

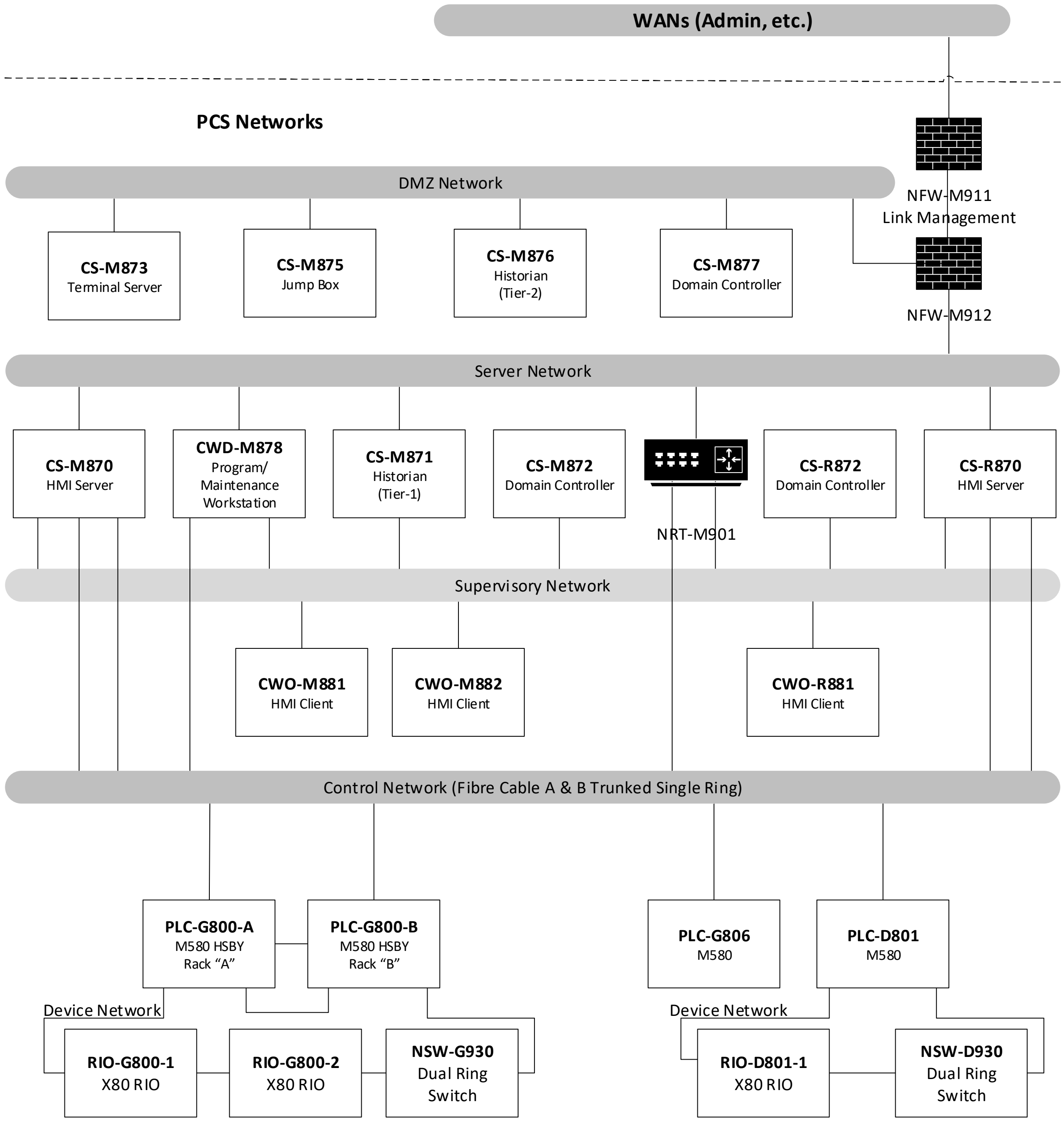


Figure 3-1: Facility PLC-based Process Control System Architecture

*Notes regarding Figure 3-1:*

1. *The figure 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. *NEWPCC equipment will have four-digit identifiers as per the Identification Standard.*
4. *Field equipment such as instruments, motor starters, VFDs, etc., are not shown.*

5. *Refer to Section 3.4.35 for additional details on the device networks for connecting field equipment.*

6. *Device tags are for reference only*

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 WAN Redundant Link Management Firewall 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 Fibre Backbone Ring Network

Provide a facility-wide fibre backbone ring that will act as the backbone for the new Process Control System Network. Provide a minimum of two redundant 24-strand fibre cables between major process areas. Eight of the strands in each 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 ring shall span the entire facility and pass through all process areas and buildings, install fibre patch panels and networking panels with spacing to ensure that:

- Copper network wiring is not required between buildings;
- Copper networking lengths are limited to 75% of their maximum design lengths;
- At least one fibre-networking panel is located in each building for connection to the fibre ring.
- Care must be taken with the network design to not exceed the limiting distance between controllers
- Networking equipment associated with the Administration and Security Networks is the responsibility of the City's IT group, and will be physically separated at all levels from the Process Control System Network (other than sharing a common fibre cable).

- Designer/ System Integrator will assign IP address based on City assignment & approval. Always confirm IP address assignment prior to implementation.

### 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 a read-only terminal server, and a jump box.
2. **Supervisory Network** – a facility-wide fibre/copper Ethernet, for communication between HMI servers, HMI clients, and portable HMI clients.
3. **Server Network** – a fibre/copper Ethernet sub-network for communication between HMI servers and historian server(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.

All connections to PCS Network devices that are not included in the approved network design are strictly forbidden without explicit authorization by the City of Winnipeg. Each of these network tiers are further described in the following sections.

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 a Domain controller, a terminal server for read-only access to the HMI system, and a jump box for managing network access.

Firewalls are used to control access in and out of the DMZ. A firewall shall be installed between the Administration Network and the DMZ. It is preferable to keep WSTP devices consistent. The firewall (NFW M912), Jump box (CS-M875), and WAN redundant link firewall in Figure 3-1will be installed 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 a minimum of 1 Gbps network speed as required.

Install a dedicated DMZ network switch for connection of the devices in the DMZ.

2. Supervisory Network

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

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 fibre or CAT6 cabling in a ring topology to feed minor process areas from adjacent major process areas. Connect HMI clients and HMI 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 servers shall operate at a minimum 1 Gbps, and the HMI clients that are connected via CAT6 cabling shall operate at a minimum of 1 Gbps.

3. Server Network

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

Redundant computer servers (e.g. the 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 a minimum of 1 Gbps network speed.

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 ring and star topology. Fibre cabling in a ring topology is used between major process areas, and CAT6 cabling is used to feed minor process areas from adjacent major process areas. The ring consists of backbone switches connected with trunk fibre strands from parallel fibre cables. Connect the HMI servers and programmable logic controllers to the network using CAT6 cabling in a star topology.

Provide dedicated redundant network switches in major process areas for each control network. The network switches are connected in serial and 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 Control Networks, in addition to the network adapter for the server network.

The control network rings shall operate at a minimum of 2 Gbps. The HMI servers and engineering workstations shall operate at a minimum of 1 Gbps, and the PLCs shall operate at a minimum of 100 Mbps.

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 Ethernet/IP, Modbus/TCP, and PROFIBUS DP/PA. The network provides high-speed connectivity to field devices such as remote I/O racks, VFDs, and MCCs, and PROFIBUS devices such as instruments and valve actuators.

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. Products should align with what is currently being used at the other Wastewater treatment plants and approved by the City.

Remote I/O racks on the 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. 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 (e.g. 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 3-1-2.

Note that a maximum of 31 RIO drops plus 64 DIO devices are supported in a single network (as of the time of writing).

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

Where equipment redundancy (e.g. Duty/Duty or Duty/Assist) is provided in the field, the associated networked devices (e.g. 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 (e.g. 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. The PROFIBUS network will be created by use of PRM gateway or PROFIBUS DP modules as required by design.

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.

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-though terminals with parallel points of connection may be provided. Include multi-master so live circuits can be tested and a device can be tested without disconnecting the circuit.

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, and 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 (e.g. 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 or PROFIBUS DP 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. 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 16.3.3 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 Ethernet Control Network Head Adapter, catalog number BMENOC0321. Install a Control Network Head Adapter module in each HSBY rack where it is required to route down to an associated device network and one on a standalone PLC where routing to the device network is required. Note that static routes will need to be configured on the programming/maintenance workstations, which is described in the Schneider Electric documentation.

Where routing capability is not provided to a particular device network, this would require maintenance personnel would bring a laptop into the field and connect to devices or the device network directly, and should only be utilized for special cases where limited, infrequently maintained devices are on the network.

A routing device is also used to facilitate communication between the Server, Supervisory and Control networks when an equipment has no direct network interface to a specific network. The communication from/to a specific network will primarily occur via the network interface directly connected. The communications between HMI Clients and Device Network are through the routing device as there is no direct network interface available.

The router (NRT-M901) in Figure 3-1 will be installed and maintained by City Wastewater Services.

### 3.4.5 Network Equipment and Cabling

Table 3-1-2 provides standard catalog numbers for typical Schneider Electric network hardware used in the Process Control System Network.

**Table 3-1-2: Standardized Networking Components**

| Purpose | Port Specifications | Model Number |
|---|---|---|
| Dual Ring Switch in Device Network | 8 x 100Base-TX | MCSESM083F23F1 |
| PROFIBUS Remote Master | 2 x 100Base-TX | TCSEGPA23F14F |

Notes;

1. For all networks above the device network layer, the make/model of the Dual Ring Switch should be consistent with what is being used throughout the wastewater treatment facilities.

Use laser-optimized 50/125 µm, multimode, OM3 cable for all new fibre installations. All fibre network switches shall use VCSEL transmitters. For distances over 750m, alternatives will be considered. These alternatives must be discussed and approved by the City.

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.

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 75% of the maximum allowable design length. This allows for the installation of patch cables and incorporates some level of contingency.

### 3.4.6 Wireless Networking

Wi-Fi access points should be provided throughout wastewater treatment facilities in electrical and control rooms and in the field where useful. Access points should be mounted on the ceiling for better coverage if possible. Provide a wireless controller/switch combination to accommodate the number of access points being installed. Make and model numbers to be approved by the City for compatibility and consistency.

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

## 3.5 HMI and Historian Server Systems

### 3.5.1 General

When a wastewater treatment facility is upgraded with a PLC based control system, provide new HMI and historian server systems based on the City's standardized goods contracts.

The following sections apply to new HMI system installations at wastewater treatment facilities.

All redundant servers at each facility to be located in separate process areas. The primary servers shall be located in the main process control system server room (typically within the Administration Building), and the secondary servers shall be located inside an automation room or server room in a different major process area. The purpose of locating the 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 automation room or server room shall be located in non-floodable areas that don't have any pipes with liquids above the area.

### 3.5.2 HMI Servers

Each HMI server consists of multiple individual software services that operate on a common hardware server. Such services include but not limited to 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. Servers should be selected by latest makes and models used in other Wastewater treatment plants and by any applicable City IT standards.

HMI servers should include a "lights out management (LOM)" server management, the same as the HP "Integrated Lights-Out" or iLO. Install HMI 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 the Primary and Secondary Control Networks, as well as the server network, as shown in Figure 3-1. Each HMI server therefore requires a minimum of three Ethernet adapters. HMI servers will use teamed NICs for redundant connection to Control Network.

### 3.5.3 HMI Clients

HMI clients should be directly connected to the HMI servers via the Supervisory Network and should directly communicate with the HMI servers which are connected to Server network. The HMI clients will not use a thin client technology which also known as Terminal Services.

Configure HMI clients to automatically login to Windows using a user account specified by the City and open the HMI application upon boot-up.

Install Aveva Historian Client and configure read only access to tier-1 historian server with autologin windows user account.

HMI Clients should be configured to connect to an HMI Server based on the preferred list in automatic mode. In case of the first choice HMI Server is not available, the client should connect to the second choice HMI Sever. In manual mode, the HMI Client should be connected to a manually designated HMI Server.

If HMI clients are installed in occupied rooms or in an area with dust or environmental concerns, fan less models shall be used.

### 3.5.4 DMZ HMI Terminal Servers

An HMI terminal server 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 (e.g. viewing SEWPCC from NEWPCC). The HMI runtime software shall be configured read-only to prevent unauthorized control of the HMI system.

The HMI client shall automatically start on user login. Install Aveva Historian Client and configure read only access to tier-2 historian server for above users.

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

Terminal server should be configured to connect to HMI Server based on the preferred list in automatic mode. In case of the first choice HMI Server is not available, the terminal server should automatically connect to the second choice HMI Sever, so on and so forth. In manual mode, the terminal server should be connected to a manually designated HMI Server.

### 3.5.5 Historian Server

Install the Historian software as defined in Standardized goods on the historian server. The number of points included should be sized for the current project and for all upcoming projects that are known at the time.

Provide a tier-1 historian server at each facility. Only one tier-1 historian server is required as the HMI servers are able to buffer data in the event that the historian server is out of service. The facility historian server shall be connected via Ethernet to the Server and Supervisory networks, as shown in Figure 3-1.

Locate the tier-1 historian server in the main process control system server room (typically within the Administration Building at the facility).

A centralized tier-2 historian may be installed on NEWPCC DMZ network or another location.

The tier-1 historian sends its replicated data to a tier-2 historian.

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. Designer/ System Integrator to provide details of data retention requirements including capacity of storage and expected duration of retention until storage is at capacity. A strategy for managing data archival and database cleanup shall be implemented. This shall be developed in consultation with City staff.

## 3.6 Modification of HMI Systems

All HMI system configurations and HMI applications shall be fully accessible and editable by the City of Winnipeg. The City shall be granted access upon start of project and will only be allowed to edit upon completion of project or handed over area. HMI hardware or software applications that are password protected and as a result made 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 two redundant domain controllers at each facility for security authentication (user login, permissions, etc.) on the supervisory network. Use domain-based security on all computers associated with the process control system, which includes the HMI servers, historian, HMI clients, programming/maintenance workstations, and laptops as applicable.

Domain security needs to be developed in consultation with the City. Scada user rights and domain user rights should be integrated. A single sign on is preferred.

The two domain controllers shall be located at two different process buildings.

One separate domain controller on DMZ is for security authentication on DMZ network.

## 3.8 Server Virtualization

Computers hosting process control system server software should use virtual machine (VM) technology to facilitate rapid recovery following a hardware or software failure. Use of server virtualization is not mandatory, but is recommended. Note that omission of server virtualization must be reviewed and approved by the City before it is omitted.

Use of server virtualization software included in RFP-XXX. Currently Schneider Electric has verified compatibility of their HMI software with VMWare ESXi. An appropriate level and version of licensing must me provided after discussion with the City.

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. This will achievable when City has full access to the servers at the beginning of project.

## 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 a minimum two (2) programming/ maintenance workstations.

Install the relevant software applications on the programming/maintenance workstations, including but not limited to:

1. Schneider Electric Aveva Plant SCADA development software,
2. Schneider Electric Vijeo Designer touchscreen HMI software,
3. Schneider Electric Eco structure Control Expertly programming software,
4. Schneider Electric Aveva Historian client, Operations Control Management Console
5. Schneider Electric SoMove motor control equipment configuration software, and
6. Adobe PDF reader or equivalent

Note: Upon transfer of workstation, System Integrator is to ensure software is of the latest version being used.

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

1. Microsoft Office
2. Adobe or equivalent
3. City of Winnipeg's current Virus protection software

Prior to securing any software confirm with City Project Management to ensure licenses have not been purchased already.

Locate the programming/maintenance workstations as directed by the City.

Connect the programming/maintenance workstations to control network, supervisory network and the server network. As such, each programming/maintenance 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 through RFP 756-2013. All processors shall be of the M580 series unless otherwise approved by the City. 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.
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 non-redundant PLC for control of non-critical equipment.
4. **Packaged PLC from Equipment Vendor** – a 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 M580 controllers in a hot-standby (HSBY) configuration with X80 series Remote I/O (RIO).

The M580 HSBY configuration requires that each processor be installed in an independent chassis. Each HSBY 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. PLCs must be powered by a UPS circuit or have local UPS backup.

Table 3-3-3 and Table 3- in Section 3.11 list the standard part numbers for the M580 HSBY 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 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 (TUs) 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 TUs can be connected to the new PLC system using custom cord sets 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, 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 cord set (e.g. 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 M580 controllers in a hot-standby (HSBY) configuration with X80 series Remote I/O (RIO).

The M580 HSBY configuration requires that each processor be installed in an independent chassis. Each 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. PLCs must be powered by a UPS circuit or have local UPS backup.

Table 3-3-3 and Table 3- in Section 3.11 list the standard part numbers for the redundant M580 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 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 potential flooding. Additionally, the control panels should not be located below grade or 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 Modicon M580 processor. I/O modules are typically located in the same chassis as the processor, but may be in a remote I/O rack if required. PLCs must be powered by a UPS circuit or have local UPS backup.

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.

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

### 3.10.4 Packaged PLC from Equipment Vendor

Where packaged PLC systems are permitted in accordance with Section 6.0 of this Design Guide the following shall apply:

Packaged PLC systems from equipment vendors may come in a variety of implementations with various brands of hardware if not specified. If possible, specify the packaged system should be based on a Schneider Electric Modicon M580 PLC, which will allow for straightforward integration with the plant process control system. PLCs must be powered by a UPS circuit or have local UPS backup.

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 (e.g. DIN rail mounted) solution.

Regarding the program within the Vendor supplied Packaged Equipment the preferred approach is to have the vendor program the PLC, based on the City's standard function block classes and consistent with the PCS programming for the entire site. If the vendor is unable or unwilling to program the PLC based on the City's standards, then the Vendor shall provide a detailed control narrative with a detailed functional requirements and communications specifications. These would be issued to the systems integrator for programming the PLC. Failing this, the vendor should, at minimum provide a control narrative, such that the design engineer is able to 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 22.3.4.4 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. Software applications that are password protected and as a result made inaccessible for modification by the City for any reason, will not be accepted under any circumstance.

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" or "C".

Standard part numbers for M580 hot-standby racks are listed in Table 3-3-33-4. Standard part numbers for X80 remote I/O racks are listed in Table 3-8.

**Table 3-3-3: M580 Hot-Standby Racks**

| Description | Catalog Number | Notes |
|---|---|---|
| Chassis, Ethernet Backplane | BMEXBP••00 | |
| Power Supply Module, 24 Vdc | BMX CPS 3020 | |
| Power Supply Module, 120 Vac | BMX CPS 3500 | |
| Processor | BME H58 •••• | See Note 1 below |
| Ethernet Communication Module | BME NOC 0311 | |
| Ethernet Control Network Head Adaptor | BME NOC 0321 | Integrated router |
| Empty Slot Filler | BMX XEM 010 | |

*Notes:*

1. *A BME H58 6040 would typically be used for DCS replacement.*

**Table 3-5: 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, Non-Isolated | BMX AMI 0800 | |
| 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.

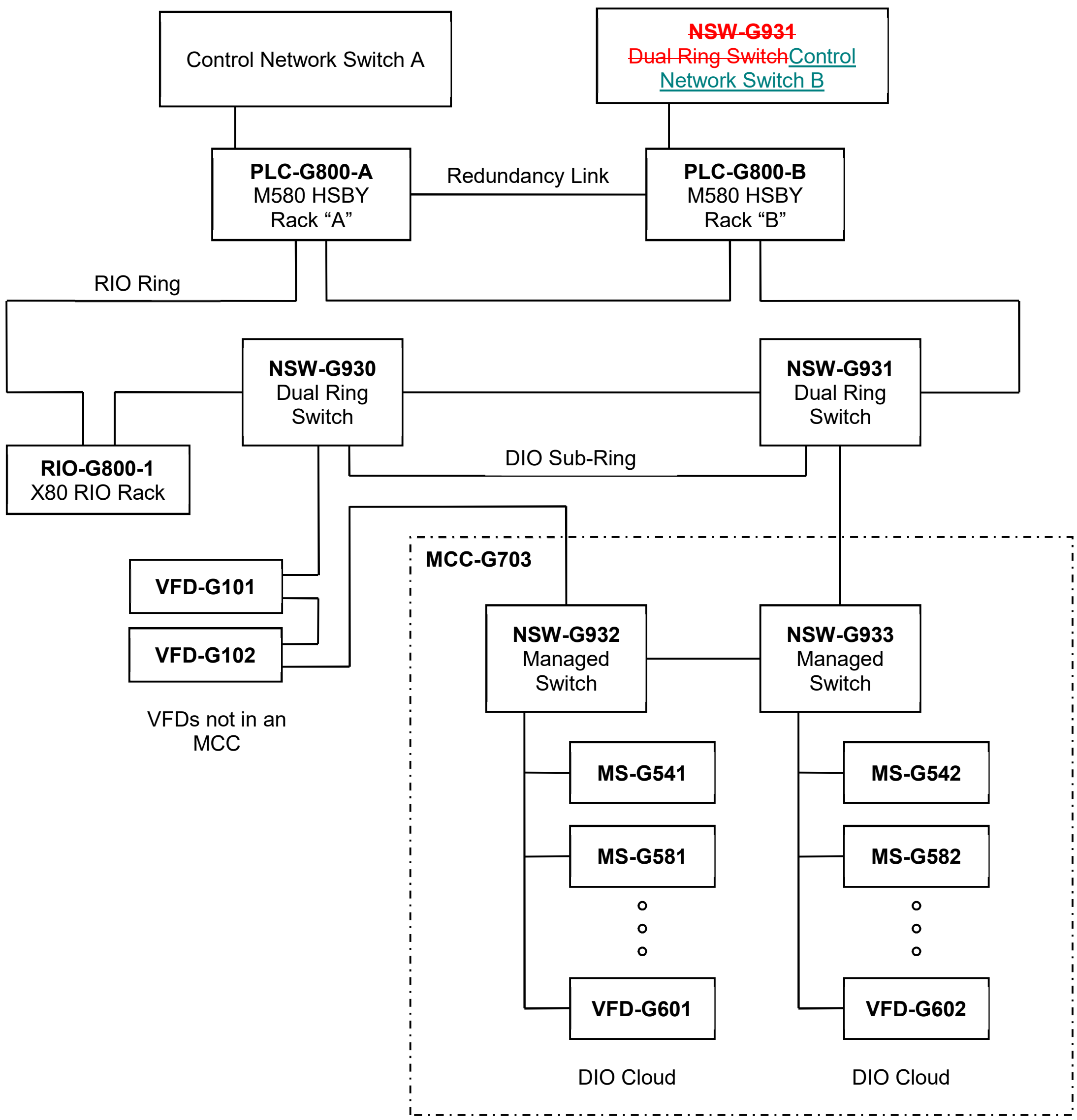


**Figure 3-2: M580 Hot-Standby Architecture**

*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.*

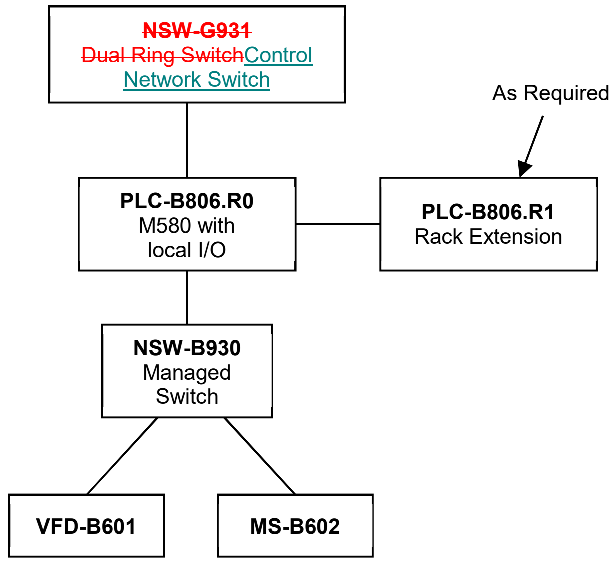


**Figure 3-3: Single M580 PLC System Architecture with Local I/O**

*Notes:*

1. *Non-redundant PLCs typically connect to one control network via the processor service port or an in-rack Ethernet module. An additional in-rack Ethernet module may be installed if connection to the Secondary Control Network is required.*
2. *Instruments are typically hardwired to in-rack I/O modules.*

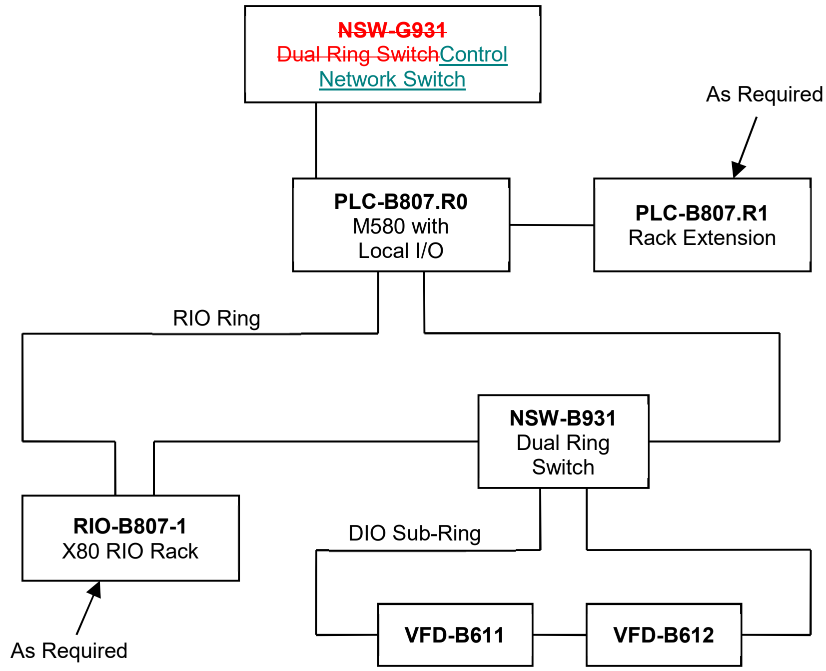


**Figure 3-4: Standalone PLC System Architecture with M580 Processor**

*Notes:*

1. *Non-redundant PLCs connect to one or both control networks via the processor service port and/or in-rack Ethernet modules.*
2. *The M580 processor may use in-rack I/O or Remote I/O (RIO).*
3. *Current M580 processor model numbers are BMEP82020 for non-redundant with no RIO racks and BMEP86040 for non-redundant with RIO racks.*
4. *Instruments are typically hardwired to in-rack I/O modules.*
5. *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.*

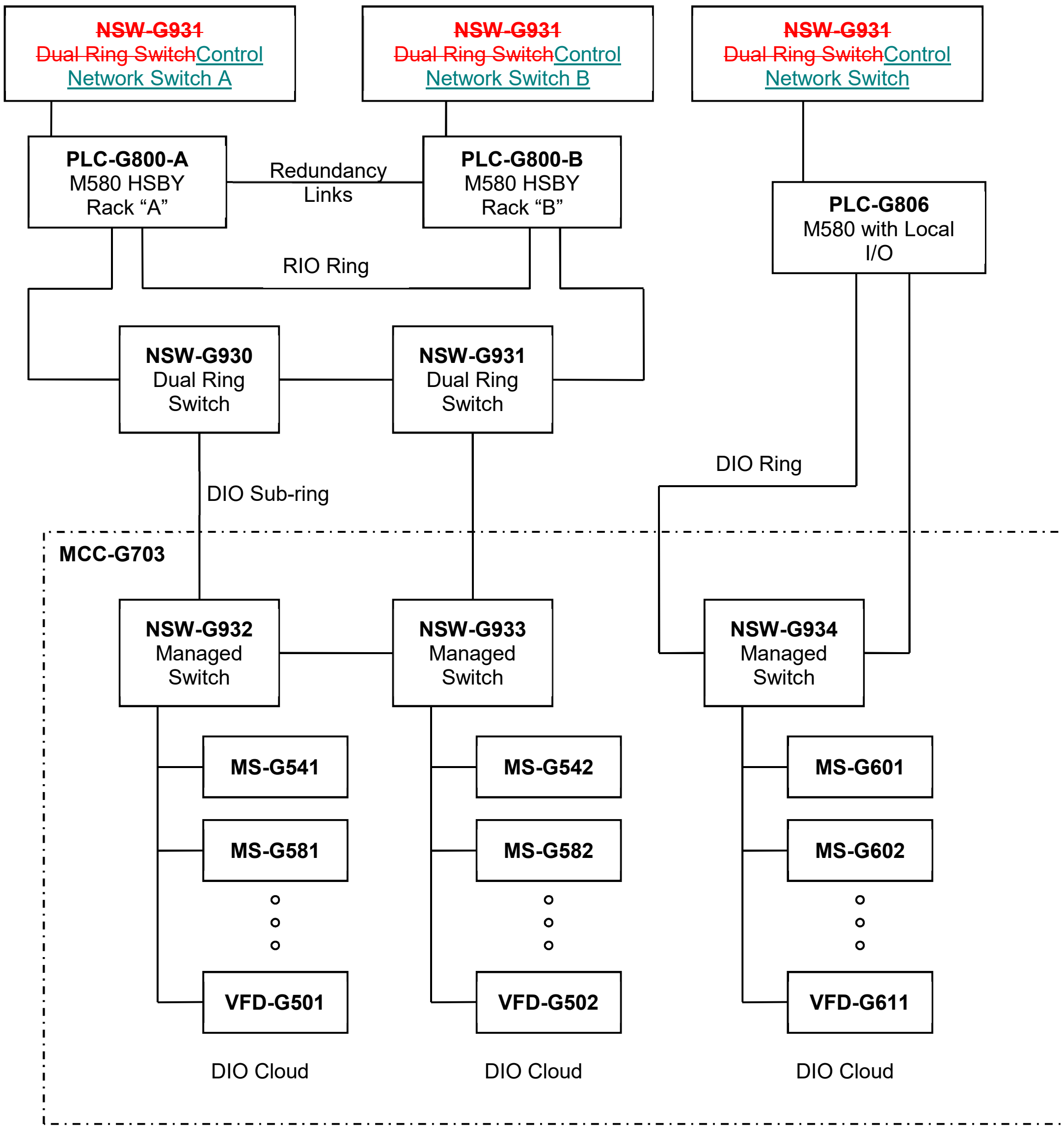


**Figure 3-5: Multiple PLCs controlling a single MCC**

*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 M580 HSBY 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.*

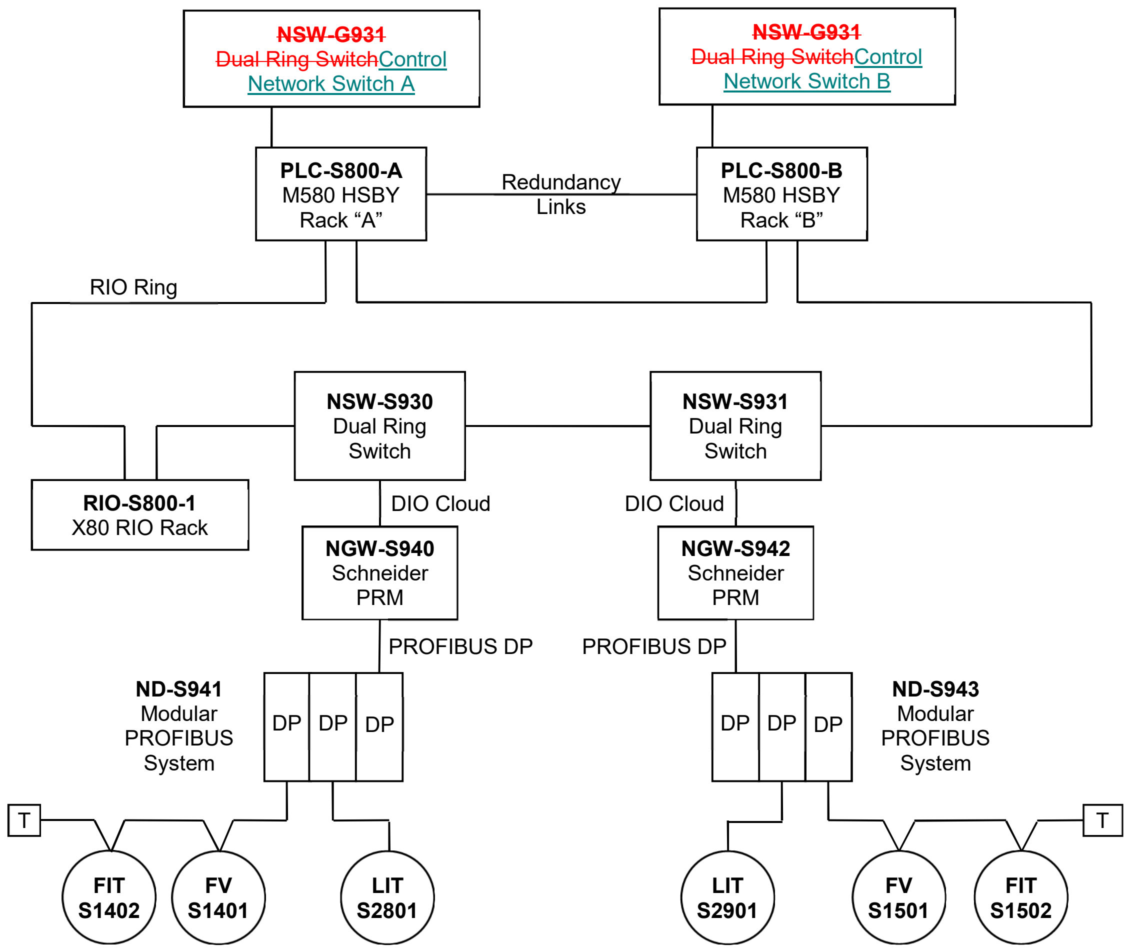


**Figure 3-6: Connection of PROFIBUS DP Devices**

*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 M580 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.*

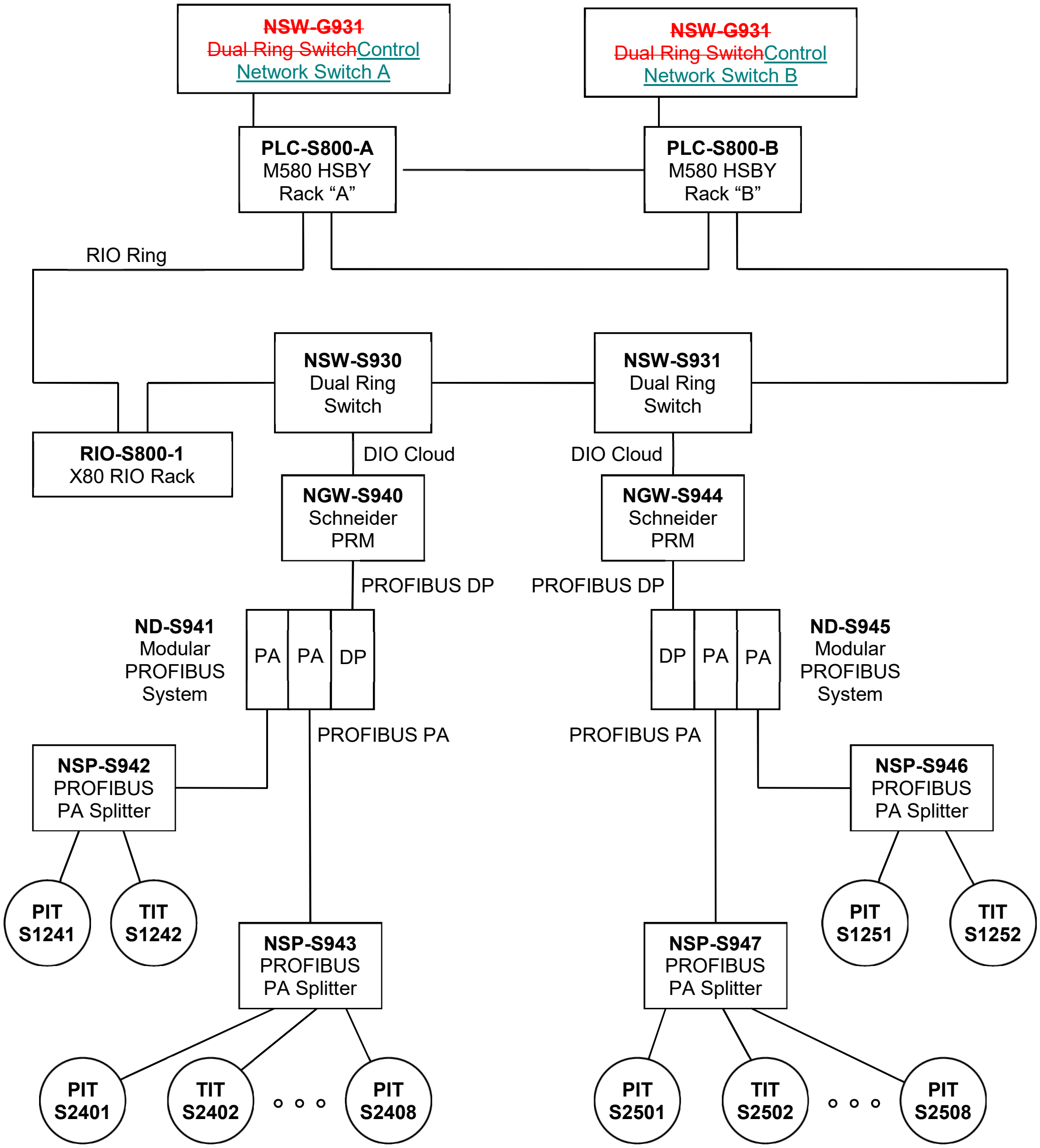


**Figure 3-7: Connection of PROFIBUS PA Devices**

*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-. Note that more than one programming language may be used within a single PLC program.

**Table 3-6-7: 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

1. All PLC configurations and program logic shall be fully accessible and editable by the City of Winnipeg. PLC systems that are password protected, and as a result made 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.
2. Programs are to be implemented using an object-oriented approach, utilizing user-defined data types and encapsulation where possible.
3. 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).
4. Use state machine logic for state-based and sequencing applications.
5. PLC configuration should support full functionality of Hot/Standby PLC systems when HSBY PLCs are utilized.
6. Refer to the City of Winnipeg Tag-name Identification Standard, document code 612620-0014-40ER-0001, for standards regarding naming of tags and function block classes.

### 3.13.3 Program Structure

1. Segregate programs into multiple tasks and routines to improve readability and maintenance of the program.
2. 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 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 by standby personnel who are not intimately familiar with the facility's operation, 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 (e.g. 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 and are derived from the WWD Electrical Design Guide:

1. Remote Auto/Remote Manual – 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.

2. Local/Off/Remote – A Local/Off/Remote switch is provided at the equipment or at the motor controller (e.g. 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. The term "REMOTE" should be used.

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 11 for further details on local controls.

## 3.15 Cyber Security

Security controls and safeguards shall be provided with all new PCS systems 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.

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. Any addition of wireless systems must be discussed with the City during design.

VPN access must be requested and granted for System Integrator remote access to PCS network.

All Ethernet network switches shall be managed switches and have all unused ports disabled. Network switches shall be password protected with the CoW or ISA standard to the most stringent requirements.

All process control system devices that incorporate password protection shall be configured with a password other than the default password with the CoW or ISA standard to the most stringent requirements. The same password should not be used on multiple devices. External authentication could be explored as an option as regular and standby O&M staff will need access.

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 (e.g. 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 and must be coordinated with the City’s IST group. Any requests for remote access should be made a minimum of 3 weeks in advance.

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, or most recent, standards and guidelines when implementing system security:

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

# 4 I/O REQUIREMENTS

Discrete inputs shall be fused as follows:

- At minimum one fuse shall be provided per I/O module. In no event shall a fuse power I/O across more than one module; and
- As minimum one fuse shall be provided per instrument / device / equipment. In no event shall a single I/O fuse be permitted to service multiple instruments / devices / equipment.

Individual fusing of each I/O point is an acceptable means to achieve the above, but is not mandatory.

Discrete input indicating fault/alarm conditions shall be wired to provide high (1) signal for normal state and low (0) signal for fault/alarm state, so that when loop wiring is broken, an alarm will be received by the control system.

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# 5 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 Water and Waste Identification Standard. All equipment shall be identified on the drawings and in the field with the same identifier.

# 6 PACKAGED EQUIPMENT SYSTEMS

## 6.1 Introduction

It is common for some complex systems to be packaged, such that the equipment vendor integrates the automation system tightly together with the equipment, to provide a comprehensive equipment package.

Packaged systems are sometimes supplied with electrical and automation control panels, such that the delivered system only requires service connections to operate. However, in other scenarios the electrical and automation components are specified and supplied independently from the package supplier so that the owner has more control over the configuration and type of electrical and automation components supplied. The City had completed an initiative to standardize on numerous electrical and automation components, and the package vendors may potentially have issues with compliance to these standards. In the even that vendors cannot comply with standardized components the contractor must provide details and reasoning to the City.

Specific wastewater treatment equipment will include packaged solutions from vendors that will include a pre-designed equipment arrangement that may be based on a proprietary design. An example of this is the potential use of high-speed turbo blowers for a BNR system, where the vendor would supply the blower complete with the VFD and integrated controls as part of a packaged unit for each blower. These packaged solutions will include equipment that has been preconfigured to achieve the performance metrics that would be established as part of the vendor’s contract obligations. Alteration of these proprietary systems could therefore impact system performance and it is likely that vendors would refuse to provide the requested performance guarantees under these circumstances. It is recognized that equipment components that form part of an overall complex system incorporating significant vendor proprietary knowledge and specialized equipment integration would be difficult to modify without impacting the vendor’s ability to meet its stated performance guarantees.

On the other hand, there are instances where part or all of a pre-packaged system includes non-complex and non-proprietary equipment configurations; where the electrical and automation controls can easily be delivered via alternate delivery approaches without significant impact upon vendor performance guarantees. These types of instances would require the vendor to include the City’s standardized equipment as part of their system.

### 6.1.1 Scenario 1 - Comprehensive Vendor Supply

Under this scenario, all package systems, including non-complex systems, are supplied with the manufacturer’s standard electrical and automation components and typically integrated into a vendor control panel. The specification would still require compliance with some of the City standards, including identification, voltage levels, etc.

#### Advantages:

The control system components would be tested and proven by the equipment supplier to properly operate the equipment.

- Single point of responsibility.
- May provide the lowest capital cost, provided the level of PCS integration is minimal.

#### Disadvantages:

- Additional spare parts must be maintained in the spare parts inventory if the manufacturer and model of supplied components are not the same as the City’s standard components.

- Additional training may be required for the City to support the electrical and automation components supplied by the package vendor.
- Service will likely require bringing in the vendor's service personnel, who may not be local and thus potentially at significant expense and operational risk.
- The manufacturer and models of the electrical and automation components may not be natively compatible with the City's future control system products. As a result, integration of the two systems may require additional components, such as protocol converters, which require configuration and are additional points of failure.
- The user interface to City personnel would likely not be consistent with the City's standards.
- As the components utilized may be proprietary, the longevity of service and support cannot be guaranteed.
- Some package vendors may desire or even insist on the ability to remote access the system for support or warranties. While this is not necessarily impossible, this would require significant coordination and City IS&T approval as well as segregation of the automation network domain to provide the appropriate security protection.

### 6.1.2 Scenario 2 – Comprehensive Vendor Supply - City Hardware and Software Standards

Under this scenario, the package vendor for non-complex systems supplies an integrated system with applicable electrical and control components, integrated into a vendor control panel. However, the hardware component manufacturer (and potentially models) would be specified in detail in the tender documents and the City standards given to the vendor to ensure that the package system supplied complies with the City's standards. In addition, City software standards would be provided to the vendor to ensure that the software produced is compliant with the City's requirements. It is assumed that the specification would require City ownership of the final software delivery.

**Advantages:**

- The control system hardware components would match the City's standard components; therefore, no compatibility issues would arise.
- Single point of responsibility.
- Less training, as the City would be familiar with the components.

**Disadvantages:**

- The manufacturer of the packaged system may be unfamiliar with the specified control components and may make errors or omissions during the implementation.
- The cost of the packaged system would increase due to potential unfamiliarity with the specified products and requirement arising from additional design efforts to implement the specified solution. In some cases, the vendor may not be able to meet the requirements.
- The level of electrical and automation shop drawing reviews required would be significantly higher due to the fact that the design may be new for the manufacturer and they are likely unfamiliar with the specified products.
- As a library of the City software standards does not currently exist, it would be difficult to provide consistency in programming between the package suppliers and the Systems Integrator.

- Where a PLC is supplied by the package vendor, the programming style would likely differ significantly from the rest of the plant, which would be programmed by the Systems Integrator.
- The manufacturer's software programmer may need to spend a significant amount of time on site debugging software, which could increase the commissioning duration.
- The user interface to City personnel would still likely have a different "look and feel" compared to the user interface provided by the Systems Integrator.
- Some package vendors may desire or even insist on the ability to remote access the system for support or warranties. While this is not necessarily impossible, this would require significant coordination and IS&T approval as well as segregation of the automation network domain to provide the appropriate security protection.

### 6.1.3 Scenario 3 –Vendor Hardware Supply - City Hardware Standards

Under this scenario, the package vendor for non-complex systems supplies an integrated system with applicable electrical and control components, integrated into a vendor control panel. Once again, the hardware component manufacturer (and potentially models) would be specified in detail in the tender documents and the City standards given to the vendor to ensure that the package system supplied complies with the City's standards. However, the programming of the controls would be omitted from the vendor's scope of work. The vendor would be responsible for providing a control narrative for the operation of the package system, which would be utilized by the main Systems Integrator for the overall project to do the programming.

#### Advantages:

- The control system components would match the City's standard components; therefore, no compatibility issues would arise.
- Less training, as the City would be familiar with the components.
- Single point of responsibility.
- Would provide a high level of consistency from a user interface "look and feel" perspective.
- The implementation details, including program methodology and the HMI animation standards, would closely match the City's standards, thereby reducing confusion for operations and maintenance personnel.

#### Disadvantages:

- The manufacturer of the packaged system may be unfamiliar with the specified control components and may make errors or omissions during the implementation.
- The cost of the packaged system would increase due to potential unfamiliarity with the specified products and requirement arising from additional design efforts to implement the specified solution.
- The level of electrical and automation shop drawing reviews required would be significantly higher due to the fact that the design is likely new for the manufacturer and they are likely unfamiliar with the specified products.

### 6.1.4 Scenario 4 – Custom Designed Approach

Under this scenario, non-complex packaged systems are supplied without the associated electrical and automation components. These would be designed in advance based upon the expected equipment supply package. The package vendor would be asked to review the electrical and control design, to ensure that it is compatible with their equipment. Note that under this scenario, standardized instruments would be supplied by the package vendor if they are installed by the package vendor on a tightly integrated skid, but would be supplied by the installation contractor if they are installed in the field. Various checks and balances would need to be set in place to ensure that the overall system operates appropriately.

Advantages:

- The control system components would match the City's standard components; therefore, no compatibility issues would arise.
- Fewer spare parts.
- Less training, as the City would be familiar with the components.
- Would provide a high level of consistency from a user interface "look and feel" perspective.
- The implementation details, including program methodology and the HMI animation standards, would closely match the City's standards, thereby reducing confusion for operations and maintenance personnel.
- All electrical and automation drawings would be standard City drawings, under the City's full ownership.

Disadvantages:

- More design drawings would be required to detail the installation of the electrical and automation components. Additional coordination work to ensure that the electrical and control system meets the requirements of the package system.
- In some cases, the manufacturer of the packaged system may try to absolve themselves of any responsibility for warranty-related issues, since they did not supply or configure the control system. This is only expected to be likely for systems with a higher level of complexity or proprietary knowledge. (This can possibly be addressed via appropriate warranty specifications)
- Some scope changes may be required for the systems integrator, based upon changes in the vendor's supply compared to that expected. However, this is dependent upon the contracting strategy.

## 6.2 Understanding of the City's Priorities

It is understood that the City places a very high value on the long-term operation and maintenance implications of equipment that is incorporated into the Three wastewater facilities. It is also understood that the City has had some previous experience with package control systems, where the maintenance has been more difficult than with custom designed solutions.

In addition, the City underwent a formal E&IC Standardisation process, which included approvals by various City departments, including IST and Corporate Support Services. The use of components different than that standardized could potentially cause issues.

## 6.3 Package System Requirements

As a general rule, it is required that all electrical and control systems shall be implemented as per Scenario 4, except where the system is complex or proprietary. The decision as to whether a package system is complex or proprietary must be made on a case-by-case basis. Refer to the table below for the packaging strategy for various systems in the Three wastewater facilities scope of supply.

**Table 6-1 : Acceptable Package Automation Systems**

| Description | Catalog Number | Notes |
|---|---|---|
| Chassis | BMX XBP ••00 | X-Bus Backplane |
| | BME XBP ••00 | X-Bus + Ethernet Backplane |

| Package System | Package Format | Notes |
|---|---|---|
| High-Speed Turbo-blowers | Scenario 1 | The complexities of the package system require complete vendor control of the deliverable. |
| Conventional Blowers (>200 hp) | Scenario 1 / 2 | It is desired that the electrical starter is fully compliant with the E&IC standardization. The automation is expected to be by the vendor. Scenario 2 is preferred, but Scenario 1 may be accepted upon discussion with and approval of the City. |
| UV System | Scenario 1 | The complexities of the package system require complete vendor control of the deliverable. However, the scope of control shall be limited to the vendor supply. |
| Centrifuge (rotating above 100 RPM) | Scenario 1 | The complexities of the package system require complete vendor control of the deliverable. However, the scope of control shall be limited to the vendor supply. |

| Package System | Package Format | Notes |
|---|---|---|
| Polymer Mixing System | Scenario 2/4 | Electrical: The 120VAC motor controls may be proprietary; however, the 600V motor controls should meet the City standards via Alternative 2 or 4.<br>Automation: Either Scenario 2 or 4 is acceptable. |
| High-Rate Clarifier | Scenario 4 | This was previously decided to be custom |
| Biofilter / Odour Control Systems | Scenario 4 | The system is not deemed to be complex or have proprietary controls. The burner controls (if any) would be proprietary and implemented under Scenario 1. The space is not expected to be conducive for significant electrical / controls installations. By selecting Scenario 4 for the electrical, it will allow the starters to be contained in an intelligent MCC. |
| Perforated Plate Screens | Scenario 4 | May have vendor provide a marshalling panel. |
| Secondary Clarifier Mechanisms | Scenario 4 | The vendor may provide instrumentation such as torque switches. |
| Chemical Feed Pump Skids | Scenario 4 | The control of the pump is simple, and does not require significant vendor involvement. It also allows the electrical to be integrated into an MCC. Instrumentation may be supplied by vendor, provided it meets City standards (i.e. flowmeter). |
| Boilers | Scenario 1 | |
| HVAC Air Handler – Natural Gas fired | Scenario 1/4 | The NG Burner management system and directly associated systems will be proprietary (Scenario 1), however all systems not part of the burner management control shall be by PLC. For example, a pre-heat coil control valve shall be controlled by the PLC. |

# 7 LAYOUT / LOCATION REQUIREMENTS

## 7.1 Control Panels

### 7.1.1 PLC Panels

PLC control panels associated with wastewater treatment process equipment should be located in dedicated automation or electrical rooms. PLC panels (containing PLC processors) are never acceptable within hazardous locations or dirty / corrosive or wet locations.

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 (e.g. Connexion switch) in a control panel may be appropriate subject to the City's approval. Networking panels should be provided in each major process area for housing the fibre switches.

### 7.1.2 Remote I/O Panels

Remote I/O panels should generally be located close to the devices that the I/O wiring connects to, which may be in the field. However, remote I/O panels shall be avoided in Class I, Zone 1 hazardous locations.

### 7.1.3 Power

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

# 8 ENVIRONMENTAL REQUIREMENTS

## 8.1 Ingress Protection

All instruments and panels/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 8-1-2 lists the minimum ingress protection for various environmental conditions.

**Table 8-1-2: 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 |

Control panels shall be located at an elevation such that they are not subject to flooding. Additionally, the control panels shall not be located below any piping that may be subject to leaks of any kind.

## 8.2 Temperature and Humidity Ratings

All automation 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.

## 8.3 Cold Environment Requirements

Instrumentation subjected to freezing conditions colder than their minimum operating temperature shall be enclosed within an insulated and heated enclosure to maintain the temperature and humidity requirements of all equipment installed within. Soft covers are not acceptable.

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

# 9 WIRING, CABLING, AND CONDUIT

## 9.1 Standard Colours

### 9.1.1 Control Wiring – Wire Colour

Wires shall be colour coded as per Table 9-1-2.

**Table 9-1-2: 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 |

### 9.1.2 Network Cable – Jacket Colour

Network cables shall be colour coded as per Table 9-3-4.

**Table 9-3-4: Network Cable Jacket Colour Codes**

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

### 9.1.3 Profibus Cable – Conductor Colour

Use the colour scheme indicated in Table 9-5-6 for all Profibus cable connections.

**Table 9-5-6: Profibus Cable Conductor Colours**

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

### 9.1.4 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 9-7-8.

**Table 9-7-8: 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.

## 9.2 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.

Use of appropriate lugs on terminal blocks and ferrules, fork lugs or ring lugs on devices

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.

### 9.2.1 Cable Requirements

Control and Instrumentation cables:

- CIC or ACIC, XLPE RW90, 600/300V, with 100% insulation.
- 600V rated cable is to be utilized for any cable termination in an enclosure containing voltages above 300V.
- Phase/polarity 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.

Ethernet Cables

CAT 6 Cable

- FT4
- Cable selection (CMP, CMP, etc.) should be appropriate for the installation.

Fibre Optic Cables:

Outdoor Fibre Optic Cable

- Fibre Requirements:
  - Single-mode
    - Fiber Category: OS2
    - Maximum Attenuation:0.4 / 0.3 dB/km
    - Chemical Resistance: RoHS
    - Approvals: CSA FT-4-ST1
    - Manufacturer and Model:
      - Corning 036EUL-T3601D2M or approved equal
  - Multi-mode
    - Fiber Category: OM3
    - Maximum Attenuation:0.4 / 0.3 dB/km
    - Chemical Resistance: RoHS
    - Approvals: CSA FT-4-ST1
    - Manufacturer and Model:
      - Corning 036EUL-T3601D2M or approved equal

Indoor Fibre Optic Cable

- In accordance with requirements of EIT/EIA 568, section 12.5
- Manufacturer:
  - Corning 040402R5Z200xxM (where xx is length in metres) or approved equal

## 9.3 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 were the use of conduits is appropriate. It is acceptable for a facility to have a mixture of conduits and cables.

Conduits shall be used 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.

## 9.4 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. This should not be used >2m. 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 9-9-10.

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

Conduit installation on unpainted concrete to be mounted with PVC spacers to prevent corrosion.

**Table 9-9-10 : 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 |

## 9.5 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.

## 9.6 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.
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.

## 9.7 Shield Termination and Grounding

1. Instrument cable overall shields and individual shields are to be grounded at one end only to avoid ground loops. The non-grounded end should be sealed with heat shrink tubing or another means so it cannot be grounded intentionally or unintentionally.
   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 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 heat shrank 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. All exposed parts of drain wires should be covered with heat shrink to ensure isolation.
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 or bus that is isolated from the safety ground, except for a single connection to the building electrode ground, to prevent ground fault currents from entering the intrinsically safe system.

## 9.8 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. Where signal noise is an issue, use of isolated analog PLC I/O modules may be considered.
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.

# 10 HMI SYSTEMS

## 10.1 Locations

The HMI clients will include desktop clients in the main control rooms and in area control rooms or determined by contract. Where walking distance to a control room is excessive, local ruggedized touchscreen terminals shall be provided near process equipment. The network connections to all fixed field operator workstations shall be hardwired.

## 10.2 Standards

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. Database status information e.g. Low space,
    h. 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 for users with appropriate privileges,
    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 (e.g. Hand, Off, Remote, etc.),
    b. Equipment operating status (e.g. 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),
   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.

## 10.3 HMI Standards and Reference Material

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

1. Tag name 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.

# 11 LOCAL USER INTERFACE

## 11.1 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.

## 11.2 Pilot Device Colours

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

**Table 11-1-2: 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 (except switchgear) | 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 |
| Stop Pushbutton | Red |
| 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:*

1. *The pilot light colours used are selected from an operations perspective.*
2. *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.*
3. *Emergency stop pushbuttons to be push-pull maintained operators with red mushroom cap.*

## 11.3 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 eight pilot devices to facilitate local control, or requires operator input or indication of analog values. Requirements for push buttons related to emergency requirements of equipment must be utilized even if HMI is provided

HMI (software) Auto/Manual modes may be provided on the HMI/PLC system to facilitate manual control of equipment via the PLC. City review is required for these situations.

The hardware and software of touchscreen HMIs should be consistent with the City's standardization agreements.

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

The use of Lock-Off-Stop (LOS) pushbuttons are prohibited for City of Winnipeg design 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 (e.g. 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. E-STOP buttons shall be included at each location of control for equipment including Control Panels (CP) & Local Control Panels (LCP)

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

# 12 CONTROL PANELS

## 12.1 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 and humidity above the minimum required for the internal components.

An additional 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.

## 12.2 Spare Space

Control panels are to be provided with a 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.

## 12.3 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 cabling/wiring.

Size wireways such that they are not more than 40% full once the wiring is installed. Wireway design should follow the CSA requirements related to wiring categories identified in Table 12-1.2.

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 12-1-2.

**Table 12-1-2: Wiring Categories**

| Category | Description | Examples |
|---|---|---|
| 1 | AC Power and Control | • AC power for power supplies<br>• 120 Vac control wiring<br>• 24 Vac control wiring to HVAC devices |
| 2 | DC Power and Control | • DC power<br>• DC control wiring |
| 3 | Analog Signals | • Analog I/O |
| 4 | Communications | • Communication cables |

## 12.4 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. The cable entry must be on the same side as the terminations in the panel so cables don't traverse the width or height of the panel.

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.

## 12.5 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, when retrofitting for existing DCS replacement, 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 on UPS feeds

## 12.6 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.

## 12.7 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 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”.

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 20 for further information on grounding.

## 12.8 Terminals

Terminals are to be provided for termination of field wiring and internal panel wiring. The standardized brand used in the Wastewater Services Division is Phoenix Contact.

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.

All field cabling/wiring and internal panel wiring to terminal blocks require lip lugs/ferrules. No bare wires allowed.\

All wiring to devices requires ferrules, fork or ring lugs unless approved by manufacturer. No bare wires allowed

## 12.9 Terminals for Hardwired I/O Terminations

The terminals listed in Table 12-3-4 are the preferred terminals for termination of hardwired I/O signals and for connection to PLC I/O modules.

**Table 12-3-4: 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 *(Note 1)* |
| Analog Input/Output, 4-wire Transmitters | 4-20 mA Signal | Disconnect Terminal |
| | 4-20 mA Common | Feed-Through Terminal |
| | Shield Drain | Feed-Through Terminal *(Note 1)* |
| 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 cord sets to connect high-density discrete I/O modules to the field terminals. These cord sets 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.

## 12.10 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 LED 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 interior light.

## 12.11 Shelves

Provide an internally-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.

## 12.12 Laptop Receptacle

A GFCI protected 120 Vac receptacle shall be provided with control panels that contain a PLC or any other equipment that is capable of Laptop connection. The receptacle should be located inside the panel and fed from 120 Vac non-essential 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.

# 13 MOTOR CONTROL

## 13.1 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.

## 13.2 Control and Monitoring

### 13.2.1 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 (e.g. 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. Devices that include clock/time functionality should synchronize to the PCS clock.

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.

### 13.2.2 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 Tess 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 13-1-2.

**Table 13-1-2: Low Voltage, Intelligent MCC Starter – Typical Control and Monitoring Points**

| **Motor Size** | **Typical Control Points** | **Typical Monitoring Points** |
|---|---|---|
| All motors | • Run command<br>• Reset command | • Local/Remote, Hand/Off/Remote, or Manual/Off/Remote switch<br>• Ready<br>• Running<br>• Fault<br>• Average motor current<br>• Accumulated run time<br>• Out of service (e.g. a communication failure) |
| ≥ 37.3 kW (50 HP) | | • 3-phase motor currents |
| ≥ 74.6 kW (100 HP) | | • 3-phase motor voltages<br>• Power factor<br>• Power<br>• 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 13-3-4.

**Table 13-3-4: Low Voltage, Hardwired MCC Starter – Typical Control and Monitoring Points**

| Motor Size | Typical Control Points | Typical Monitoring Points |
|---|---|---|
| All motors | • Run command | • Local/Remote, Hand/Off/Remote, or Manual/Off/Remote switch<br>• Ready<br>• Running<br>• Overload tripped |
| ≥ 37.3 kW (50 HP) | | • Motor current (single phase)<br>• Accumulated run time<br>• Starts per hour |
| ≥ 187 kW (250 hp) | | • 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.*

### 13.2.3 Low Voltage Variable Frequency Drives

The City has standardized variable frequency drives for low voltage applications in the sewage treatment program. Refer to the Electrical Design Guide, document 510276-0000-47ER-0001 for VFD requirements.

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 City requires VFD's 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 13-5-6 and Table 13-7-8, respectively.

**Table 13-5-6: Low Voltage, Networked VFDs – Typical Control and Monitoring Points**

| Motor Size | Typical Control Points | Typical Monitoring Points |
| --- | --- | --- |
| All motors | • Run command<br>• Speed command<br>• Reset command | • Local/Remote, Hand/Off/Remote, or Manual/Off/Remote switch<br>• Ready<br>• Running<br>• Motor speed<br>• Motor current (3-phase average)<br>• Accumulated run time<br>• Last protection fault<br>• Starts per hour<br>• Out of service (e.g. 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 13-7-8: Low Voltage, Hardwired VFDs – Typical Control and Monitoring Points**

| Motor size | Typical Control Points | Typical Monitoring Points |
| --- | --- | --- |
| All motors | • Run command<br>• Speed command | • Local/Remote, Hand/Off/Remote, or Manual/Off/Remote switch<br>• Ready<br>• Running<br>• Motor speed<br>• Motor current (3-phase average)<br>• Accumulated run time<br>• VFD faulted<br>• 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.*

### 13.2.4 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 13-9-10.

**Table 13-9-10: Medium Voltage Motors – Typical Control and Monitoring Points**

| Motor size | Typical Control Points | Typical Monitoring Points |
| --- | --- | --- |
| All motors | • Run command<br>• Speed command (VFD applications only) | • Local/Remote, Hand/Off/Remote, or Manual/Off/Remote switch<br>• Ready<br>• Running<br>• Motor speed (VFD applications only)<br>• 3-phase motor current<br>• Accumulated run time<br>• 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.*

### 13.2.5 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.

# 14 VALVE CONTROL

## 14.1 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 shall 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

## 14.2 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 14-1-2.

**Table 14-1-2: Typical Valve Control and Monitoring Points**

| Valve and Actuator Characteristics | Typical Control Points | Typical Monitoring Points |
|---|---|---|
| Open/Close Valve,<br>Solenoid Actuated,<br>Hardwired | • Open Command | N/A |
| Small valves<br>(≤ 102 mm),<br>Open/Close,<br>Electric Actuator,<br>Hardwired | • Open and Close Command | • Open and Closed Limit (as required) |
| Small valves<br>(≤ 102 mm),<br>Modulating,<br>Electric Actuator,<br>Hardwired | • Position Command (4-20 mA) | • Position Feedback (4-20 mA) |
| Medium/Large<br>(> 102 mm)<br>Open/Close,<br>Electric Actuator,<br>Hardwired | • Open Command<br>• Close Command | • Remote Selected<br>• Open Limit<br>• Closed Limit<br>• Fault |
| Medium/Large<br>(> 102 mm)<br>Modulating,<br>Electric Actuator,<br>Hardwired | • Position Command (4-20 mA)<br>• Stop/Maintain Command | • Remote Selected<br>• Position Feedback (4-20 mA)<br>• Open Limit (optional)<br>• Closed Limit (optional)<br>• Fault |
| Open/Close Valve,<br>Electric Actuator,<br>PROFIBUS Communication<br>*(See Note 1)* | • Open command<br>• Close command | • Actuator Moving<br>• Closed Limit<br>• Open Limit<br>• Running Closed<br>• Running Open<br>• Remote Selected<br>• Local Stop Selected<br>• Local Selected<br>• Thermostat Tripped<br>• Monitor Relay<br>• Valve Obstructed<br>• Valve Jammed<br>• Valve Moving by Hand<br>• Moving Inhibited<br>• Position Control Enabled<br>• Watchdog Recovery<br>• Battery Low<br>• Control Contention |

| Valve and Actuator Characteristics | Typical Control Points | Typical Monitoring Points |
|---|---|---|
| Modulating Valve,<br>Electric Actuator,<br>PROFIBUS Communication<br>*(See Note 1)* | • Position command | • Valve Position<br>• Actuator Torque<br>• Actuator Moving<br>• Closed Limit<br>• Open Limit<br>• Running Closed<br>• Running Open<br>• Remote Selected<br>• Local Stop Selected<br>• Local Selected<br>• Thermostat Tripped<br>• Monitor Relay<br>• Valve Obstructed<br>• Valve Jammed<br>• Valve Moving by Hand<br>• Moving Inhibited<br>• Position Control Enabled<br>• Watchdog Recovery<br>• Battery Low<br>• Control Contention |
| On/Off Valve,<br>Pneumatic Control | • Open Command<br>• Close Command | • Closed Limit<br>• Open Limit |
| Modulating Valve,<br>Pneumatic Control | • Position Command | • 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.*

# 15 SPECIFIC APPLICATION REQUIREMENTS

## 15.1 Building Mechanical Systems

1. All Building Mechanical systems shall be monitored and controlled by the plant PCS. An independent commercial-grade Building Management System (BMS) shall not be utilized.
2. All Building Mechanical control and monitoring shall be by PLC, consistent with the WSTP Automation Design Guide. No exceptions shall be permitted except for the following:
   - 2.1 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.
   - 2.2 Boilers and chillers may utilize packaged controls that do not fully comply with the WSTP Automation Design Guide. Ensure integration into the plant PCS is consistent with the Automation Design Guide and meets operational requirements.
   - 2.3 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.
3. In situations where package HVAC controls are permitted in accordance with the above, the following requirements apply:
   - 3.1 Associated drawings shall clearly identify the wired devices and their locations.
   - 3.2 All interlocks shall be clearly documented for maintenance personnel.
   - 3.3 When an interlock is not met, there shall be a clear indication of the specific interlock not being met to maintenance personnel.
   - 3.4 As-built drawings shall be provided.
   - 3.5 Setpoint control of boilers, chillers, and air handling units shall be from the plant PCS via a coordinated interface.
   - 3.6 Alarms shall be provided from the package unit to the PCS.
4. Where possible and practical, utilize separate PLCs, dedicated to Building Mechanical systems rather than connecting to process-based PLCs. Note that all PLCs are part of a common PCS.

# 16 INSTRUMENTATION

## 16.1 General Requirements

1. The instrumentation identified as requirements in this document shall not be construed as limiting the instrumentation requirements for a complete system that meets all requirements.

2. Unless specifically identified, all instrumentation shall be connected to the PCS with appropriate integration into control strategies and alarming.

## 16.2 Typical Practices

### 16.2.1 Fail-Safe Implementation

Where hardwired methods are used for connection of switches and/or relays used for alarming purposes, the switches and/or relays shall be wired in a fail-safe implementation, meaning that the switch is closed/relay coil is energized during normal operation and opens/releases 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.

### 16.2.2 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. Signal cabling shall be designed to ensure that any interference is neutralized or mitigated, the use of dedicated conduits for such cabling is recommended.

### 16.2.3 Instrument Redundancy

Where failure or inaccuracy of a single instrument has unacceptable consequences, instrument redundancy shall 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 (e.g. 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.

### 16.2.4 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.

### 16.2.5 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.

### 16.2.6 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.

### 16.2.7 Gas Detection Equipment

Fixed gas detection equipment shall be provided with a means for calibrating and testing the equipment at an accessible location. Some sensors need to be mounted on the ceiling or other readily inaccessible location, and as such will be difficult to access. Sensors shall be provided with means to attach 6 mm (1/4") I.D. stainless steel tubing, and the tubing shall be routed down to a location that is readily accessible to personnel and near the transmitter display.

Gas detection transmitters shall be provided with a local display and configured to indicate the gas concentration in units of % LEL.

A gas detection alarm shall be indicated with both a visual and audible alarm, where the visual alarm consists of a flashing red light.

### 16.2.8 Hazardous Location Door Entry Stations

Provide a door entry station at each door to a hazardous location where entry into the area is only permitted based on certain operating criteria. Examples include areas where the ventilation system is used to maintain a lower area classification, or a dual-rate ventilation system that must run at the high rate when the area is occupied by personnel.

The door entry station shall be equipped with coloured lights to indicate whether entry is permitted based on the information available to the control system. Provide a green light to indicate there are no known hazards (e.g. the ventilation system is running and no gas alarm is present, etc.), and that entry is therefore permitted. Provide a red "Do Not Enter" light to indicate that entry is not permitted due to ventilation system failure, the presence of a gas alarm, or other hazardous condition.

For dual-rate ventilation systems that operate at the high rate when occupied, provide a selector switch (or utilize the light switch) to allow personnel to switch to the high rate operation prior to entry. While the system is ramping up to the high ventilation rate, flash the red "Do Not Enter" light to indicate that this switch has been turned on but the system has not yet reached the high ventilation rate. Once the system has reached the high ventilation rate and no other hazards are known to exist then turn the red flashing light off and turn the green light on to signal that entry is permitted.

Note that in addition to door entry stations, an audible alarm should also be provided inside the area to alert personnel of a ventilation system failure.

## 16.3 Selection Criteria

### 16.3.1 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: MSA.
Address: 12134 – 154 Street NW, Edmonton, AB T5V 1J2

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.

### 16.3.2 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.

### 16.3.3 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.

New analytical instruments, electromagnetic flowmeters, level transmitters, temperature transmitters, and pressure transmitters used for process applications should utilize a PROFIBUS output wherever possible. Some analytical instruments may be unavailable with a PROFIBUS output, in which case a Modbus/TCP output should be utilized instead. Replacement of existing 4-20 mA-based transmitters with PROFIBUS transmitters is not generally required during wastewater treatment plant upgrades, but this may be performed where desired. For non-process applications, such as an HVAC system, use of 4-20 mA output is generally preferred due to simplicity and cost.

Transmitters for process applications without a PROFIBUS output should incorporate a 4-20 mA output with HART protocol. 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 Wireless HART or ANSI/ISA 100.11a technology. Note that the wireless versions of Siemens instruments use Wireless HART. 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 down-time resulting from wireless system failure. All wireless instrumentation applications shall be reviewed with and approved by the City prior to implementation.

### 16.3.4 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 16-1-2.

**Table 16-1-2: 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. |
| Pump Low Flow Detection | Switch | Partial testing with pump on/off cycling provided. |
| | Transmitter | Where there is use as part of process measurement. |
| Ventilation Low Airflow Detection | Switch | On/off fans.<br>Partial testing with fan on/off cycling provided. |
| | Transmitter | Variable speed fans |
| Instrument Air Low Pressure | Transmitter | Continuous indication of operation. |

### 16.3.5 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.

### 16.3.6 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 8.1. All instrumentation accessories and mounting hardware shall be stainless steel.

### 16.3.7 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 16-3-4 lists acceptable electromagnetic flowmeter liner materials for various types of media.

**Table 16-3-4: Acceptable Electromagnetic Flowmeter Liner Materials**

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

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

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

### 16.3.8 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 (e.g. 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.

### 16.3.9 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.

### 16.3.10 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.

## 16.4 Application Requirements

### 16.4.1 HVAC – Air Systems

Provide instrumentation for HVAC filtration in accordance with Table 16-5. Connect all transmitters and switches to the PCS for monitoring, alarming, and control as applicable.

**Table 16-5 : Filter Instrumentation**

| **Application** | **Additional Criteria** | **Instrumentation Functions** | **PCS Functions** (See Note 2) |
|---|---|---|---|
| Minimum Requirement if none of the below applies | | PDG, PDSH (See Note 1) | PDAH |
| Systems serving electrically classified spaces | | PDT, PDG | PDI, PDAH, PDAHH |
| Systems serving hazardous chemical spaces | | | |
| Systems where a plugged filter may impede human occupancy | | | |
| Filters on a media filtration system | | | |
| Systems with a design capacity ≥ 1,000 L/s | | | |

*Notes:*

1. *The instrumentation functions indicated may be integrated. Please reference the City Tag naming standard*
2. *The PCS functions are typical minimum requirements and are not exhaustive. For functions not defined submit to City for review and approval.*

**Table 16-6 : Damper Instrumentation**

| **Application** | **Additional Criteria** | **Instrumentation Functions** | **PCS Functions** (See Note 2) |
|---|---|---|---|
| Motorized on/off damper | | ZSC, ZSO | XC, ZLC, ZLO |
| Modulating damper | | ZT | *C (See Note 3), ZI |

*Notes:*

1. *The instrumentation functions indicated may be integrated. Please reference the City Tag naming standard*
2. *The PCS functions are typical minimum requirements and are not exhaustive. For functions not defined submit to City for review and approval.*
3. *The initiating variable for the damper depends on the application. Typical initiating variables are T and P.*

**Table 16-7 : Air Flow Instrumentation**

| **Application** | **Additional Criteria** | **Instrumentation Functions** | **PCS Functions** (See Note 1) |
|---|---|---|---|
| Supply air – Electrically classified hazardous locations | Used to lower the electrical classification as per NFPA 820 | FIT (See note 3) | FI, FAL, FALL, FAH, FAHH |
| | Design flow capacity ≥ 500 l/s | | |
| | Occupied at a frequency ≥ 1 per month | | |
| Exhaust air – Electrically classified hazardous locations | Used to lower the electrical classification as per NFPA 820 | | |
| | Design flow capacity ≥ 500 l/s | | |
| | Occupied at a frequency ≥ 1 per month | | |
| Supply air - unclassified location | Design flow capacity ≥ 4000 l/s | | |
| Exhaust air – unclassified location | | | |
| Return air - unclassified location | | | |
| Chemical- Under Development | | | |

*Notes:*

1. *The PCS functions are typical minimum requirements and are not exhaustive. For functions not defined submit to City for review and approval. Designer/Integrator will create functions to meet the needs of the application*
2. *The flow rates indicated are the total flow for the system or space, whichever is greater.*
3. *Thermal dispersion type unless otherwise approved by the City.*

**Table 16-8 : Pressure Instrumentation – HVAC Air Systems**

| **Application** | **Additional Criteria** | **Instrumentation Functions** | **PCS Functions** (See Note 1) |
|---|---|---|---|
| Room – Entire room is Class I, Zone 1 | | PDIT (See Note 2) | PDI, PDAL, PDALL, PDAH, PDAHH |
| Room – Entire room is Class I, Zone 2 and may contain partial Class I, Zone 1 areas | Area ≥ 100 $m^2$ | | |
| | Has an opening into a Class I, Zone 1 location (See Note 3) | | |
| | Has an opening into an unclassified location (See Note 3) | | |
| | Has two or more, or variable, ventilation rates | | |
| Room – Contains Class I, Zone 2 area(s) but is not completely classified | Has an opening into a Class I, Zone 1 location (See Note 3) | | |
| Room – Unclassified | Has an opening into a Class I, Zone 2 location (See Note 3) | | |
| Any | Where a hazard could be introduced by a pressurization failure that would not be otherwise alarmed to the PCS. | | |

*Notes:*

1. *The PCS functions are typical minimum requirements and are not exhaustive. For functions not defined submit to City for review and approval. Designer/Integrator will create functions to meet the needs of the application*
2. *The room differential pressure will be measured relative to atmospheric pressure.*
3. *Openings include doors and openable windows, as well as process connection openings where there could be a Secondary grade of release as per IEC 60079-10-1.*

**Table 16-9 : Temperature Instrumentation – HVAC Air Systems**

| Application | Additional Criteria | Instrumentation Functions | PCS Functions (See Note 2) |
|---|---|---|---|
| Coil – Heating or cooling with risk of freezing | | TSL (See Note 3) | TAL |
| Outdoor air duct | | TT | TI |
| Mixed air duct (outdoor air and return air) | | TT | TI, TAL, TAH |
| Reheat air duct (After heat recovery or initial heating unit / coil) | | TT | TI, TAL, TAH |
| Supply air duct | | TT | TI, TAL, TALL, TAH, TAHH |
| Room < 10 $m^2$ and routinely occupied (See Note 4) | | TT | TI, TAL, TALL, TAH, TAHH |
| Room ≥ 10 $m^2$ | | | |
| Room with different zones or temperature profiles during normal or abnormal operation | | Multiple TT as required. | |

*Notes:*

1. *The instrumentation functions indicated may be integrated.*
2. *The PCS functions are typical minimum requirements and are not exhaustive. For functions not defined submit to City for review and approval. Designer/Integrator will create functions to meet the needs of the application*
3. *Hardwire interlock the low temperature switch with the supply air fan and other equipment as required.*
4. *Control rooms require temperature transmitters.*

**Table 16-10 : Valve Instrumentation**

| Application | Instrumentation Functions | PCS Functions (See Note 2) |
|---|---|---|
| Motorized on/off valve | ZSC, ZSO | XC, ZLC, ZLO |
| Modulating valve | ZT | *C (See Note 3), ZI |

*Notes:*

1. *The instrumentation functions indicated may be integrated.*
2. *The PCS functions are typical minimum requirements and are not exhaustive. For functions not defined submit to City for review and approval. Designer/Integrator will create functions to meet the needs of the application*
3. *The initiating variable for the damper depends on the application. Typical initiating variables are T.*

**Table 16-11 : Miscellaneous Instrumentation**

| Application | Instrumentation Functions | PCS Functions (See Note 2) |
|---|---|---|
| Motorized on/off valve | ZSC, ZSO | XC, ZLC, ZLO |
| Modulating valve | ZT | *C (See Note 3), ZI |

*Notes:*

4. *The instrumentation functions indicated may be integrated.*
5. *The PCS functions are typical minimum requirements and are not exhaustive. For functions not defined submit to City for review and approval. Designer/Integrator will create functions to meet the needs of the application*
6. *The initiating variable for the damper depends on the application. Typical initiating variables are T.*

## 16.4.2 Building Sumps (Non-Process)

1. Sumps with potentially significant flows of water that could present a flooding situation in the event of an instrument / control failure shall be provided with a secondary failsafe activation device. This instrument may be in common with the high sump level alarm instrument.
2. Provide a high-level sensor for all sumps, connected to the PCS for alarming. The high-level sensor shall be independent of the level instrumentation for primary pump control. Acceptable product types are:
   2.1 Flygt ball;
   2.2 Rod-based float switch; and
   2.3 Capacitance probe.
3. Provide ultrasonic-based instrumentation for pump control for sump pumps. Provide a stilling chamber as required.

## 16.4.3 Gas Detection

1. General Requirements
   1.1 Provide a sufficient quantity of gas detection systems to adequately cover the entire space that is or may be occupied. Do not assume that a single gas detection sensor is sufficient to cover an entire room or space.
   1.2 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.
   1.3 Locate gas detection systems at the appropriate elevation, considering the toxic or hazardous gas density, ventilation patterns, and location of personnel.
   1.4 Utilize continuous sample draw based gas detection systems for:
      16.4.3.1.4.1 Locations where access is difficult, or there is significant impediment to occupancy; and
      16.4.3.1.4.2 Applications where pre-conditioning of the sample is required to provide sample accuracy or extended sensor life.

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 (Profibus preferred). The only exception is that carbon monoxide sensors may simply transmit a discrete alarm to the plant PCS.

1.7 Provide means to calibrate all gas detection instruments without the use of temporary ladders, scaffolding, etc. This may require provision of remote calibration systems.

1.8 Provide visual and audible alarms in accordance with the Automation Design Guide. Ensure alarms are configured with setpoints that protect personnel from exceeding exposure limits; however, extraneous alarms shall be avoided while the space is unoccupied.

2. For $H_2S$ gas detection:

2.1 Provide sensors capable of monitoring $H_2S$ levels as low as 1 ppm.

3. For combustible gas detection:

3.1 Utilize long-life infrared-based detectors wherever possible.

3.2 Provide alarming upon gas levels that equal or exceed 5% of the lower explosive limit.

3.3 Where spaces have more than one rate of ventilation, interlock gas detection with ventilation / odour control systems to set ventilation at the highest level upon combustible gas levels that equal or exceed 10 percent of the lower explosive limit.

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

3.5

### 16.4.4 Permanent Gas Detection

1. Provide permanent fixed gas detection for hazardous and toxic substances as follows:

1.1 In accordance with Table 16-12;

1.2 Carbon Monoxide (CO) sensors in all locations where direct gas-fired equipment is utilized;

1.3 Oxygen deficiency sensors in all locations where there is an oxygen displacement risk, including all spaces with a floor elevation 10 meters or more below grade;

1.4 As required by codes and regulations; and

1.5 As appropriate based upon Good Industry Practice.

2. Provide permanent fixed gas detection for combustible gasses as follows:

2.1 In accordance with NFPA 820;

2.2 As required by codes and regulations; and

2.3 As appropriate based upon Good Industry Practice.

**Table 16-12: Permanent Gas Detection of Toxic and Hazardous Substance - Minimum Requirements**

| Occupancy (See Note 1) | Normal Concentration (See Note 2) | Expected Abnormal Concentration (See Note 3) | Permanent Gas Detection Required |
|---|---|---|---|
| < 1 per year | Any | Any | No |
| ≥ 1 per year AND < 1 per week | < TLV-TWA | Any | No |
| | ≥ TLV-TWA | Any | Yes |
| ≥ 1 per week AND < 1 per day | < TLV-TWA | < TLV-STEL | No |
| | | ≥ TLV-STEL | Yes |
| | ≥ TLV-TWA | Any | Yes |
| ≥ 1 per day | < TLV-TWA | < TLV-TWA | No |
| | | ≥ TLV-TWA | Yes |
| | ≥ TLV-TWA | Any | See Note 4 |

*Note(s):*

1. *The Occupancy includes any period of occupancy by any personnel, of any duration.*
2. *The Normal Concentration includes both periods of occupancy and non-occupancy.*
3. *The Expected Abnormal Concentration is based upon the failure of any equipment or component.*
4. *Not acceptable as per exposure limits*

3. Comply with code and functional specification regarding implementation of gas detection controls.

### 16.4.5 Chemical Rooms

1.1 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.

1.2 High speed ventilation shall be triggered by the gas or spill detection if available.

### 16.4.6 Smoke Detectors

1. Provide duct smoke detectors only where required by the National Building Code or local code requirements.

### 16.4.7 Security

**Table 16-13 : Door Monitoring**

| **Application** | **Additional Criteria** | **Instrumentation Functions** | **PCS Functions** (See Note 1) |
|---|---|---|---|
| Door is between an unclassified location and a Class I, Zone 2 location | | ZSC (See Note 2) | ZAO (Typically with time delay) |
| Door is between a Class I, Zone 2 location and a Class I, Zone 1 location | | | |
| | | | |
| | | | |

*Notes:*

1. *The PCS functions are typical minimum requirements and are not exhaustive. For functions not defined submit to City for review and approval.*
2. *Ensure door switch is rated for the higher electrical classification.*

# 17 POWER SUPPLY

## 17.1 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. These panels are to be fed from UPS/Utility 120Vac Feeds with redundant 120Vac to 24Vdc power supplies and Redundancy module

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.

## 17.2 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.

Power supplies should be redundant.

module when loads can only support a single input.

## 17.3 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 (e.g. 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 17-1-2 indicates the requirement for UPS power for various types of process control system equipment.

**Table 17-1-2: 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 | Yes |
| Process Related PLCs and I/O | Yes |
| Non-Process Related PLCs and I/O | Yes |
| Process Related Instruments | Yes |
| Non-Process Related Instruments with exception to emergency requirements related to security, HVAC and gas detection. | Optional |
| Emergency Shutdown Systems | Yes |
| Programming/Maintenance Workstations and Monitors | Yes |

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 17-3-4: 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.

# 18 HAZARDOUS LOCATIONS

## 18.1 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 filings (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.

## 18.2 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. Explosion proof 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.

## 18.3 Design Requirements

### 18.3.1 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 μJ. Examples of simple apparatus include simple contacts, thermocouples, RTDs, LEDs, and non-inductive potentiometers and resistors.

### 18.3.2 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 (e.g. 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 (e.g. 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, 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 20 for additional information on grounding.

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

## 18.4 Preferred Methods of Protection

### 18.4.1 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.

### 18.4.2 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.

### 18.4.3 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.

### 18.4.4 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.

# 19 SAFETY INSTRUMENTED SYSTEMS

## 19.1 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 considered, 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.

## 19.2 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 (e.g. 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. (e.g. 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.

## 19.3 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.

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.

# 20 GROUNDING

## 20.1 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 24 Vdc 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 12.7, 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 (e.g. 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.

As per the electrical code, separate grounding systems may not be provided for a single building and therefore the automation grounds are not completely independent from 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.

If only one or two PLCs or HMI clients are being installed in a building, installation of a dedicated automation ground 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.

Further discussion on the implementation of automation equipment grounding is provided in Section 20.2.

## 20.2 Implementation of Automation Equipment Grounding

### 20.2.1 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 (e.g. 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.

### 20.2.2 Installations in New Buildings

New buildings shall be constructed with dedicated automation grounding points. 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 as required.

### 20.2.3 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 (e.g. 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 20-1 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 20-2 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.

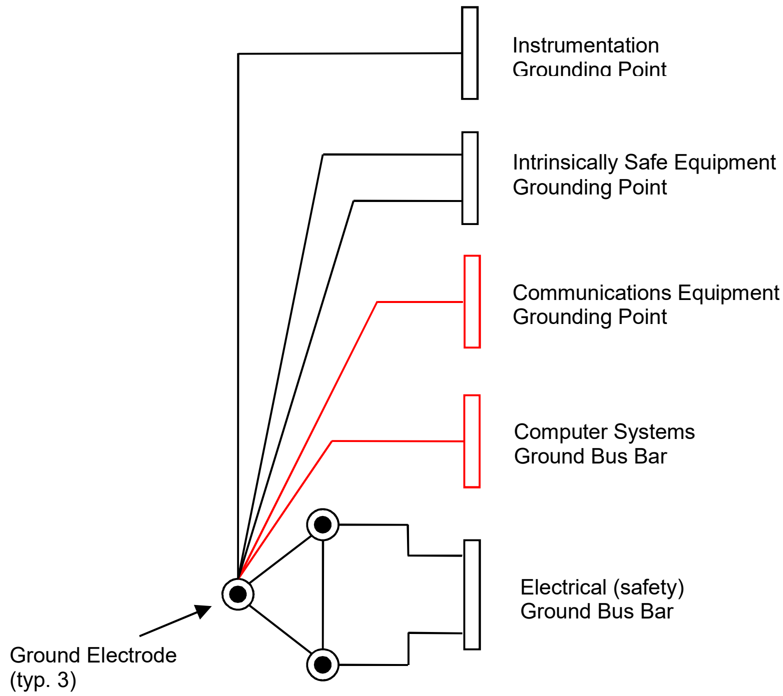


**Figure 20-1: Typical Grounding System Implementation with Three Grounding Electrodes**

*Notes:*

1. *The electrical (safety) ground bus bar is grounded to two ground electrodes to ensure proper connectivity to ground.*
2. *The instrumentation and intrinsically safe ground bus bars 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.*

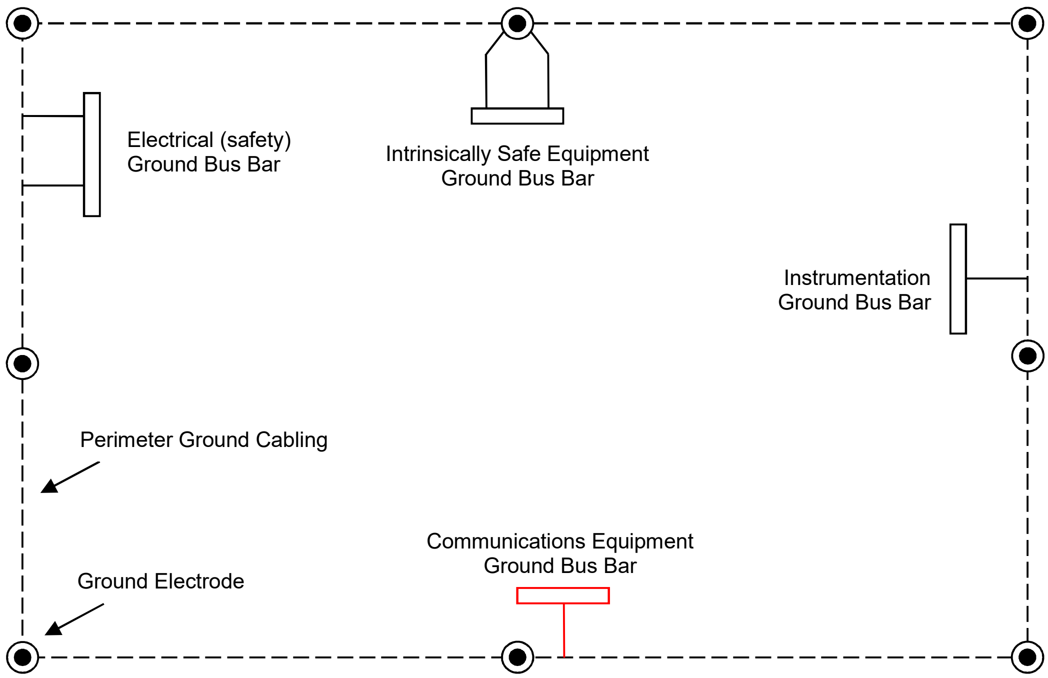


**Figure 20-2: Typical Grounding System Implementation with a Perimeter Ground**

*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 is 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 it 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.*

## 20.3 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 12.7.

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.

## 20.4 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 18.3.2 for further information on grounded associated apparatus.

# 21 AUTOMATION ROOMS

## 21.1 Location of Equipment

## 21.2 General Requirements

Requirements of automation rooms include the following:

1. Ensure bare concrete floors are covered, painted, or sealed to reduce the build-up of concrete dust on automation equipment. Use of conductive surface hardeners for concrete floors is not permissible.
2. Locate automation rooms a minimum of 150mm above outdoor grade level.
3. Where automation rooms are subject to potential flood risk from a nearby process upset, locate the electrical room a minimum of 100 to 150 mm above the process floor level, or higher as required, to prevent a process flood incident from flowing into the electrical room.
4. No process piping shall run through the automation room.
5. No washroom or kitchen facilities shall be allowed directly above an automation room.
6. Hot water or glycol heating pipes or heaters shall not be located above automation rooms or anywhere such that a leak of liquid or steam could conceivably enter an automation room.
7. Evaporating coils for air handling units will be located and arranged to prevent condensation from running onto automation equipment in the event of a plugged drain.
8. Housekeeping pads:
    - 8.1 It is generally preferred that automation equipment be installed on housekeeping pads. Housekeeping pads are required in any application where there is potential for water leakage on the floor.
        - 21.2.1.8.1.1 Housekeeping pads may be omitted where not compatible with certain types of draw-out switchgear.
    - 8.2 Size housekeeping pads to extend 50mm past the equipment.
    - 8.3 Housekeeping pads to be between 110 and 152 mm high.
    - 8.4 Provide rebar as structurally required, but at minimum provide 10M rebar spaced at maximum 300 on center and anchor to the floor.

## 21.3 Space and Location Requirements

1. Design new automation rooms to provide a minimum of 25% usable floor space not allocated to installed equipment at the end of the project. In addition, a minimum of 10% of usable wall space shall be spare. This space provision shall not be utilized for equipment that only becomes defined as the project progresses.

*Note: A common issue is that not all the electrical and automation equipment are known at the time of electrical room sizing. Automation room sizing at the preliminary design stage may need to be 150 – 200% of the size required for the equipment known at this stage. Consider undefined requirements at the time of automation room sizing.*

# 22 ENGINEERING DESIGN TEAM RESPONSIBILITY

## 22.1 General

1. Responsibility for deliverables:
    1.1 All drawings and other deliverables related to a design are the responsibility of the design engineer.
    1.2 The design team shall verify the make/model numbers used in this document are the most recent, compatible versions of the product offering.
2. All automation deliverables are to be sealed by a qualified professional engineer.
    2.1 The commissioning of the local SCADA system (HMI, workstations, etc.) shall be completed prior to the commissioning of any process area. If new servers and/or historians are added as part of the project they should be also be commissioned prior to the commissioning of process areas.
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.

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/Information.

8.3 The Design Team is responsible for reviewing the completed acceptance test forms to ensure that the installation complies with the specifications.

## 22.2 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.

### 22.2.1 Architecture Block Diagrams

A High-level view of networks, showing interconnections (routers/firewalls), servers, workstations, printers etc. for SCADA system, and PLCs, devices etc. for control/device networks.

### 22.2.2 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, where there are multiple load devices within the loop, indicate the impedance of each device in the loop.

2.5 Indicate the source of power (and common / neutral connections) for all loops.

2.6 Provide an appropriate symbol within each special terminal to indicate the type of terminal:

2.6.1 Indicate fused terminals with a small fuse symbol inside the terminal. Provide the fuse rating below the terminal.

2.6.2 Indicate disconnect terminals with a small disconnect symbol inside the terminal.

2.6.3 Indicate potential earth terminals with a small ground symbol inside the terminal.

2.7 Show the instrument identifier within an instrument bubble symbol adjacent to and pointing at the instrument.

2.8 Show all field instrument and control panel device part numbers on loop drawings.

2.9 For intrinsically safe wiring, indicate the following:

2.9.1 The classification of the hazardous location (e.g. Class I, Zone 1, Group IIC),

2.9.2 For intrinsically safe apparatuses (field devices) other than simple devices, the manufacturer, model, and entity parameters of the apparatus,

2.9.3 Manufacturer/model and/or permissible entity parameters of the associated apparatus (e.g. IS barrier),

2.9.4 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.

### 22.2.3 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.

### 22.2.4 Instrument Location Plan Drawings

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

### 22.2.5 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 line weight.

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

### 22.2.6 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.

### 22.2.7 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 (e.g. “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.

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).

### 22.2.8 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.

### 22.2.9 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 22.2.3.

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”.

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 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. ***Note IP addresses are not to be made available to the public.***

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.

## 22.2.10 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 contactor 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.

### 22.2.11 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.
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 (e.g. 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 (e.g. 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 22.3.7) together with the Functional Requirements Specifications (Section 22.3.8) 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 (e.g. 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.

## 22.3 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. The design team shall verify the make/model numbers used in this document are the most recent, compatible versions of the product offering.

All documents converted to PDF format shall be searchable.

### 22.3.1 Instrument List

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

### 22.3.2 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 (e.g. loop drawings, P&ID drawings)

2.1.4 Notes

2.1.5 Revision of last change

## 22.3.3 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 (e.g. 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 tag name) (previous/superseded name if applicable)

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)

2.2.5.3 Indicate which state is used for alarms (if applicable)

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) including raw min and max if scaling occurs in SCADA rather than in the PLC. Indicate engineering unit of measure

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.

## 22.3.4 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 Tag name,
      3.2.2 Protocol Address (e.g. 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 In the case of packaged control systems alarm limits should also be indicated
      3.2.8 Digital I/O, should identify, register number and bit number and 1 and 0 states (alarm, etc.)
      3.2.9 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.

## 22.3.5 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.

   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.

### 22.3.6 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.

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.

### 22.3.7 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 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 (e.g. 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 equipment protection interlocks.

2.11 Indicate required minor and major alarms.

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.

### 22.3.8 Functional Requirements Specifications

An Enhanced Process Control Narrative (PCN) and function block manual should be developed for all new or migrated areas instead of Functional Requirements Specifications.

## 22.4 Construction and Commissioning Documents

### 22.4.1 Instrument Test Forms

1. Requirement:

   1.1 Instrument test forms shall be provided with projects where new instruments will be installed. Checklists shall be formatted to contain all deliverables of the design requirements.

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.

## 22.4.2 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. Checklists shall be formatted to contain all deliverables of the design requirements.

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 tag name, 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.

### 22.4.3 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. Checklists shall be formatted to contain all deliverables of the design requirements.

2. Preparation and Completion:

2.1 PLC system commissioning checklists shall be prepared by the Design Engineer and filled in by the Systems Integrator.

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 are acceptable.

3.4.5 Communications between PLC and remote racks are 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.

## 22.4.4 SCADA System Commissioning checklist

5. Requirement:

5.1 SCADA system commissioning checklists shall be provided for new SCADA installations for verification that each SCADA system is installed and operating correctly. Checklists shall be formatted to contain all deliverables of the design requirements.

6. Preparation and Completion:

6.1 SCADA system commissioning checklists shall be prepared by the Design Engineer and filled in by the Systems Integrator.

7. Content:

7.1 Provide a header section at the top with the following fields, to be filled in by the contractor:

7.1.1 Facility

7.1.2 Project Name

7.1.3 Plant Area

7.1.4 Bid Opportunity number

7.1.5 Document number

7.2 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.

7.3 Provide a section for filling in the HMI/Server identifier, HMI/Server description, processor and network adapter module numbers, and rack number.

7.4 Provide a section indicating that the following has been inspected:

7.4.1 Redundancy check for redundant systems – we need to check and make sure all redundancy system works including the network.

7.4.2 Ensure hardware meets COW specs.

7.4.3 Ensure all required applications are installed on the servers and workstations/clients are working as designed.

7.4.4 Ensure all SCADA server alarms are operational.

7.4.5 Ensure the HMI and all graphic displays (i.e. header/footer, navigation, trends, alarms, etc.) are working/operational.

7.4.6 There should be a commissioning checklist for all servers to ensure they are setup/working as designed.

7.4.7 Test the thin clients (if applicable) to ensure they are working as designed.

7.4.8 Test the networks (DMZ, Supervisory, Server, Primary and Secondary) to ensure they are working as designed.

7.5 Provide a section for filling in any other commissioning checks applicable to the SCADA system.

8. Format:

8.1 HMI system commissioning checklists will typically be prepared in Microsoft Word, but other formats may be accepted by the City with approval.

### 22.4.5 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. Checklists shall be formatted to contain all deliverables of the design requirements.

2. Preparation and Completion:

2.1 Valve actuator commissioning checklists shall be prepared by the Design Engineer and filled in by the installation contractor.

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.

## 22.5 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.

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 19.

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.

# 23 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 |

# 24 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 |

Winnipeg

# The City of Winnipeg

## Water & Waste Department

# Wastewater
# Historical Data Retention Standard

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|---|---|---|
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# TABLE OF CONTENTS

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# 1 INTRODUCTION

This Water and Waste Department Historical Data Retention Standard is intended to serve as a reference for ensuring consistent retention and archival of data produced by the control systems at City of Winnipeg owned wastewater facilities. This document provides guidance to department personnel, as well as external consultants, regarding historical data retention requirements.

## 1.1 Scope of the Standard

This document is intended to convey general guidance regarding the historical retention of data produced by the control system at wastewater facilities. It is not meant to provide guidance on the legal or regulatory requirements of the various Acts and regulations governing wastewater treatment facilities. However, these documents were used in the development of this standard, and references are provided for information.

This document does not address specifics related to equipment type, selection, and configuration. 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 control system historian with general conformance to the concepts presented herein.

Data produced by means other than the control system is not addressed by this document. This includes offline laboratory analysis, operator measurements, and data from local controllers not connected to the plant historian.

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.

## 1.2 Application

These design requirements will apply to all City of Winnipeg wastewater treatment plants. 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 Reference Documents

- The Environment Act (Province of Manitoba) - C.C.S.M. c. E125
- Limitation of Actions Act (Province of Manitoba) - C.C.S.M. c. L150
- Canada Water Act (R.S.C., 1985, c. C-11)
- Canadian Environmental Protection Act (S.C. 1999, c. 33)
- Wastewater Systems Effluent Regulations (The Fisheries Act) - SOR/2012-139

# 2 GENERAL PRINCIPLES

## 2.1 Availability of Data

The control systems at City of Winnipeg wastewater facilities are capable of monitoring and generating extremely large amounts of data concerning the operation, maintenance, and performance of the wastewater treatment process. This data is available to be archived in a historian database for access at a later date. The archived data may later be used to re-create trends and observe operating conditions from a given timeframe for a variety of purposes including maintenance, troubleshooting, performance monitoring, and regulatory approval.

## 2.2 Archival Principles

The amount of data archived by a historian can quickly grow to a very large volume if left unmanaged. Although modern storage devices are capable of storing extremely large amounts of data, it is poor design practice to archive more data than is necessary. As an archive is allowed to grow in size, the associated hardware and maintenance costs required to store the data also increase substantially. Backup copies of the archives similarly take longer to create and require additional storage media. Excessively large historical archives also decrease the efficiency of queries and retrieval.

To help ensure the efficiency and effectiveness of the control system historian, archival retention guidelines corresponding to the expected useful life of various types of data are specified in Section 3.1. In addition to configuring the historian software to conform to these guidelines, provisions must be made to ensure that the hardware and software required to access the historical data is maintained throughout the lifetime of the historical records. Alternatively, as the historian hardware and software nears the end of its lifespan, the historical data may be exported to a format that is easily accessed and widely supported at that time.

# 3 REQUIREMENTS FOR TYPICAL APPLICATIONS

## 3.1 Recording Interval Requirements

The majority of modern historian software packages are able to dynamically adjust the recording interval of analog data to more rapidly capture rapid changes in values. Similarly, data that does not vary within a pre-defined deadband is sampled at a much slower rate. This allows rapid changes in value to be captured with higher resolution, while avoiding unnecessary logging of points that do not substantially change for long periods of time. In general, deadband and sampling settings must be configured to allow for re-construction of significant spikes and deviations in data.

As with analog data, discrete data is typically recorded at a variable rate wherein only changes in state are recorded. Thus, the logging interval will vary directly in proportion to the number of state and event changes observed.

Because of these dynamic logging capabilities for both discrete and analog data, the Recording Intervals shown in Table 3-1 through Table 3-8 are an order-of-magnitude estimation of the average interval between consecutive samples for each type of data, rather than a pre-set recording interval.

## 3.2 Retention Periods

The minimum retention periods for various types of information recorded by the control system are shown in Table 3-1 through Table 3-8. Each type of data is categorized as either discrete or analog data. It is anticipated that analog data will require a larger amount of storage per point than the discrete data primarily due to more frequent variation in value. As such, the retention period of analog data is generally shorter than that of discrete data. Despite this, certain analog data that is important for regulatory and environmental protection purposes, such as effluent flow and field-mounted analytical instrumentation data, shall be maintained for an extended period of time. Additionally, the majority of the most important data for many analog points may be captured by recording the average, minimum, or maximum value over a longer time period (hourly or daily), resulting in fewer samples.

The minimum retention period selected for most operational and process data is 2 years. This is based on the Limitation of Actions Act for the Province of Manitoba, which generally requires that most types of legal action take place a maximum of 2 years following an incident. The Canada Water Act and the Canadian Environmental Protection Act similarly have a limitation period of 2 years. Additionally, the Environment Act for the Province of Manitoba requires that data be retained for at least 2 years in the event of any deviations from normal operating procedures, along with any details of equipment failure or maintenance.

A brief survey of guidelines for data retention in other provincial and state wastewater jurisdictions showed that historical data is typically retained for a minimum of 3 - 5 years. As such, the minimum retention periods selected for most types of historical data does not exceed 5 years. A notable exception is historical data pertaining to overall plant performance, such as effluent sample analysis and effluent flows. As this data is critical to assessing and tracking overall plant performance and environmental impact, extended retention of this data is recommended.

The retention times noted only apply to data stored on the plant historian, and the City may choose to keep data for longer periods as part of their internal record keeping.

The following tables contain generalized guidelines for different types and classes of equipment. It is anticipated that there will be exceptions and additions to these guidelines. Exceptions are to be reviewed and approved on a case-by-case basis.

### 3.2.1 Overall Performance Data

Overall performance data shows the performance of the wastewater plant as a whole, as well as its environmental impact. Retention of this data over an extended period of time is recommended.

**Table 3-1 : Data Retention – Overall Performance Data**

| Data Type | Recording Interval * | Minimum Retention | Notes |
|---|---|---|---|
| Plant Influent Flow | Minute | 2 yrs | |
| Plant Influent Flow Hourly Total | Hour | 20 yrs | |
| Plant Influent Flow Daily Total | Day | 20 yrs | Calculated from hourly flow totals |
| Influent Analytical Data | Minute | 1 yr | Currently an offline measurement ** |
| Influent Analytical Data Daily Avg/Max | Day | 20 yrs | |
| Intermediate Analytical Data | Minute | 1 yr | Currently an offline measurement ** |
| Intermediate Analytical Data Daily Avg/Max | Day | 20 yrs | |
| Effluent Analytical Data | Minute | 1 yr | Currently an offline measurement ** |
| Effluent Analytical Data Daily Avg/Max | Day | 20 yrs | |
| Plant Effluent Flow | Minute | 2 yrs | |
| Plant Effluent Flow Hourly Total | Hour | 20 yrs | 5 years retention required for the Fisheries act |
| Plant Effluent Flow Daily Total | Day | 20 yrs | Calculated from hourly flow totals |

* *Recording Intervals are an order-of-magnitude estimation of the average interval between consecutive samples for each type of data, not a pre-defined recording interval or sampling rate*

** *Recording interval and retention period shown as a guideline for possible future inclusion in control system automated measurement and recording*

### 3.2.2 Major Equipment Data

Historical data associated with major equipment is likely to be useful in evaluating overall process performance, and helping to determine the cause of failures. Major equipment has the most direct impact on the process, so it is recommended that its historical data be kept for a longer period of time, as compared to historical data for other types of equipment.

Within historical data collected from major equipment, analog data that directly measures process flows and levels should be retained for longer periods of time. Similarly, discrete points that record failure and alarm states have the most potential to provide information relevant to determining the cause of process failures and inefficiencies, and should be retained longer. Analog data that may prove useful for equipment maintenance, but does not directly measure process performance shall be discarded after a shorter period of time.

Some examples of major equipment include:

- Sewage Pumps
- Grit Screens
- Grit Tanks and Pumps
- Clarifiers
- Sludge Pumps
- Reactors
- Aeration Blowers
- Digesters
- Dewatering Centrifuges
- Nitrogen and Phosphorus Removal Equipment
- Chemical Feed Systems

**Table 3-2 : Data Retention – Major Equipment Data**

| Data Type | Recording Interval * | Minimum Retention | Notes |
|---|---|---|---|
| **Analog Data** | | | |
| Motor Speed | Minute | 5 yrs | |
| Valve Position | Minute** | 5 yrs | |
| Tank Level<br>Hourly Min / Max / Average | Hour | 5 yrs | |
| Flow Total Indication | Hour | 5 yrs | |
| Miscellaneous analytical data<br>Hourly Min / Max / Average | Hour | 5 yrs | e.g. Turbidity, Dissolved Oxygen |
| **Discrete Data** | | | |
| Equipment Start/Stop | Event | 5 yrs | |
| Valve Open / Close | Event | 5 yrs | |
| Trouble / Warning Alarms | Event | 10 yrs | |
| Failure Alarms | Event | 10 yrs | |
| **Analog Maintenance Data** | | | |
| Motor / Pump Vibration | Minute | 2 yrs | |
| Motor / Pump Vibration Daily Max | Day | 5 yrs | |
| Motor / Pump Bearing Temperature | Minute | 2 yrs | |
| Motor / Pump Bearing Temp Daily Max | Day | 5 yrs | |
| Motor Winding Temperature | Minute | 2 yrs | |
| Motor Winding Temperature Daily Max | Day | 5 yrs | |
| Motor Amps Average | 15 Minute Average | 5 yrs | |
| Oil Temperature Average | 15 Minute Average | 5 yrs | |

* *Recording Intervals are an order-of-magnitude estimation of the average interval between consecutive samples for each type of data, not a pre-defined recording interval or sampling rate*

** *To limit the amount of storage required for Valve Position data, the resolution of the recorded valve position may be set sufficiently coarse to limit the number of samples stored.*

### 3.2.3 Minor Equipment Data

Minor equipment may or may not be directly related to the process, but the value of the equipment is typically much lower than the major equipment and may have a lower impact on the overall process performance.

Historical data associated with minor equipment will be useful in maintenance planning and diagnostic activities, but may be less useful in determining the cause of overall process issues. Minor equipment has less direct impact on the process, so it is recommended that its historical data be retained for a shorter interval.

Some examples of minor equipment include:

- Valves – Electric Actuated
- Valves – Solenoid
- Sluice/Slide Gates

**Table 3-3 : Data Retention – Minor Equipment Data**

| Data Type | Recording Interval * | Minimum Retention | Notes |
|---|---|---|---|
| **Analog Data** | | | |
| Motor Speed | Minute | 3 yrs | |
| Valve Position - Modulating | Minute** | 3 yrs | |
| Tank Level<br>Hourly Min / Max / Average | Hour | 3 yrs | |
| Flow Total Indication | Hour | 3 yrs | |
| Miscellaneous analytical data<br>Hourly Min / Max / Average | Hour | 3 yrs | e.g. Turbidity, Dissolved Oxygen |
| **Discrete Data** | | | |
| Equipment Start/Stop | Event | 5 yrs | |
| Valve Open / Close | Event | 5 yrs | |
| Trouble / Warning Alarms | Event | 5 yrs | |
| Failure Alarms | Event | 5 yrs | |
| **Analog Maintenance Data** | | | |
| Motor / Pump Vibration | Minute | 2 yrs | |
| Motor / Pump Vibration Daily Max | Day | 10 yrs | |
| Motor Amps | 15 Minute Average | 5 yrs | |

* *Recording Intervals are an order-of-magnitude estimation of the average interval between consecutive samples for each type of data, not a pre-defined recording interval or sampling rate*

** *To limit the amount of storage required for Valve Position data, the resolution of the recorded valve position may be set sufficiently coarse to limit the number of samples stored.*

### 3.2.4 Auxiliary Equipment Data

Historical data associated with auxiliary equipment may be useful in the troubleshooting and maintenance of that particular equipment, but is unlikely to prove to be important in the direct analysis of process performance. As such, this data will typically be retained for a shorter duration.

Auxiliary equipment is generally not directly part of the process, but will provide miscellaneous services to allow for overall operation of the facility. Some examples of auxiliary equipment include:

- HVAC
- Hot Water Pumps
- Cooling Water Pumps
- Glycol Pumps
- Heat Exchangers
- Potable water system
- Sump pumps

**Table 3-4 : Data Retention – Auxiliary Equipment Data**

| Data Type | Recording Interval * | Minimum Retention | Notes |
|---|---|---|---|
| **Analog Data** | | | |
| Motor Speed | Minute | 2 yrs | |
| Valve Position | Minute | 2 yrs | ** |
| Tank Level<br>Hourly Min / Max / Average | Hour | 2 yrs | |
| Flow Total Indication | Hour | 2 yrs | |
| **Discrete Data** | | | |
| Equipment Start/Stop | Event | 3 yrs | |
| Valve Open / Close | Event | 3 yrs | |
| Trouble / Warning Alarms | Event | 5 yrs | |
| Failure Alarms | Event | 5 yrs | |
| **Analog Maintenance Data** | | | |
| Motor / Pump Vibration | Minute | 2 yrs | |
| Motor / Pump Vibration Daily Max | Day | 5 yrs | |
| Motor Amps | 15 Minute Average | 2 yrs | |

* *Recording Intervals are an order-of-magnitude estimation of the average interval between consecutive samples for each type of data, not a pre-defined recording interval or sampling rate*

** *To limit the amount of storage required for Valve Position data, the resolution of the recorded valve position may be set sufficiently coarse to limit the number of samples stored.*

### 3.2.5 Fire, Gas Detection, and Security

Although fire, gas detection, and security equipment does not typically directly affect the process, it is important from a health and safety perspective.

**Table 3-5 : Data Retention – Security and External Access Data**

| Data Type | Recording Interval * | Minimum Retention | Notes |
|---|---|---|---|
| **Analog Data** | | | |
| Hazardous gas level | Minute | 3 yrs | |
| Hazardous gas daily maximum | Day | 20 yrs | |
| **Discrete Data** | | | |
| Security Alarm / Trouble | Event | 5 yrs | |
| Door open/close | Event | 3 yrs | |
| Motion Sensor | Event | 3 yrs | |
| Fire Alarm / Trouble | Event | 5 yrs | |
| Hazardous Gas Alarm | Event | 5 yrs | |

* *Recording Intervals are an order-of-magnitude estimation of the average interval between consecutive samples for each type of data, not a pre-defined recording interval or sampling rate*

### 3.2.6 Electrical Distribution Equipment

Interruptions to the electrical distribution may be very disruptive to the process. Logging major events in the primary and backup power supplies will aid in analysis of process disturbances resulting from power supply disturbances.

**Table 3-6 : Data Retention – Electrical Distribution Equipment**

| Data Type | Recording Interval * | Minimum Retention | Notes |
| --- | --- | --- | --- |
| **Analog Data** | | | |
| Main Switchgear Voltage, Current, Power, Power Factor | Minute | 5 yrs | |
| Main Switchgear Harmonics | Hour | 5 yrs | |
| Individual MCC Voltage, Current, Power, Power Factor | Minute | 3 yrs | |
| Individual MCC Harmonics | Hour | 3 yrs | |
| Main Switchgear and MCC Daily Maximum, Minimum, and Average Voltages | Day | 5 yrs | |
| Generator Voltage, Current, and Power | Minute | 2 yrs | While generator is running |
| Generator Vibration, Exhaust Manifold Temperature, Oil Temperature, Oil Pressure, and Fuel Consumption | Minute | 2 yrs | While generator is running |
| Generator Vibration, Exhaust Manifold Temperature, Oil Temperature, and Oil Pressure Daily Max | Day | 5 yrs | While generator is running |
| **Discrete Data** | | | |
| Main / Tie Breaker Status | Event | 5 yrs | |
| Generator Start / Stop | Event | 5 yrs | |
| Generator Fault | Event | 5 yrs | |
| UPS Alarms | Event | 5 yrs | |
| Transfer Switch Operation | Event | 5 yrs | |

* *Recording Intervals are an order-of-magnitude estimation of the average interval between consecutive samples for each type of data, not a pre-defined recording interval or sampling rate*

### 3.2.7 Control System Equipment

Failures in the control system hardware and associated communications network are likely to disrupt control and monitoring of the process. Logging control system status information will aid in analysis of process disturbances resulting from these events.

**Table 3-7 : Data Retention – Control System Equipment**

| Data Type | Recording Interval * | Minimum Retention | Notes |
| --- | --- | --- | --- |
| **Analog Data** | | | |
| Network Traffic Hourly Avg / Max | Hour | 3 yrs | |
| **Discrete Data** | | | |
| Network Switch Alarms | Event | 3 yrs | |
| Control Network Communications Alarms | Event | 3 yrs | |
| Control System Power Supply Alarms | Event | 3 yrs | |
| Profibus Network Communications Alarms | Event | 3 yrs | |
| PLC Module Fault | Event | 3 yrs | |
| Cyber-Security Related Event Logs | Event | 3 yrs | |

* *Recording Intervals are an order-of-magnitude estimation of the average interval between consecutive samples for each type of data, not a pre-defined recording interval or sampling rate*

### 3.2.8 Operator Action Data

Operator Action Data refers to the record data of all operator commands issued from the HMI, field device panels, and local equipment controls (if they are monitored by the control system). Operator commands, and particularly setpoints, are crucial in understanding the operation of the wastewater facility. This data is usually required to reconstruct a sequence of events after a significant abnormal operating event. The importance of this historical data, combined with relatively low frequency of operator commands, merits longer minimum retention times for this data.

**Table 3-8 : Data Retention – Operator Action Data**

| Data Type | Recording Interval * | Minimum Retention | Notes |
|---|---|---|---|
| **Discrete Events** | | | |
| Login / Logout | Event | 5 yrs | |
| Equipment Operation | Event | 5 yrs | |
| Alarm Acknowledgement | Event | 5 yrs | |
| **Analog Setpoints** | | | |
| Setpoint Changes | Event | 5 yrs | |

* *Recording Intervals are an order-of-magnitude estimation of the average interval between consecutive samples for each type of data, not a pre-defined recording interval or sampling rate*

## 3.3 Archival Requirements

Control system historical data will primarily be archived on the local hard drive of the historian server. Consequently, this historian hardware must incorporate some form of local data redundancy. This may include a redundant set of hard drives or storage devices in RAID (Redundant Array of Independent Disks) configuration, or a hot-standby Historian server.

In some rare cases, the size of the historical data archive may exceed the storage capacity of the historian server hardware, resulting in the historian server being only able to maintain a rolling window of the most recently collected data. If this situation cannot be avoided by limiting data archival, historical data will need to be periodically copied to a means of external storage in order to maintain a complete archive of historical data.

## 3.4 Backup and Disaster Recovery Requirements

In addition to the local redundancy provided by RAID storage and server hardware redundancy, measures must be taken to maintain an off-site copy of historical data to safeguard it against physical harm at the local facility. Nightly incremental backups to an off-site server would protect the historical data archive in the event of a catastrophic event at the wastewater facility.

# The City of Winnipeg

## Water & Waste Department

# HMI Layout and Animation Plan

Document Code:

Revision: 03

| | | |
| --- | --- | --- |
| Approved By: | Colin Javra, P.Eng<br>Project Director – Winnipeg Sewage Treatment Program | March 7, 2023<br>Date |

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| | | | | | |
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# TABLE OF CONTENTS

# 1 INTRODUCTION

This Wastewater Department HMI Layout and Animation Plan is intended to serve as a reference for consistent implementation of new HMI software applications for City of Winnipeg owned wastewater facilities. This document provides guidance to department personnel, as well as external consultants and external contractors, in the implementation of HMI systems for the Winnipeg Sewage Treatment Program (WSTP).

## 1.1 Scope of the Document

These implementation requirements apply to HMI systems at the following facilities:

- North End Sewage Treatment Plant (NEWPCC),
- South End Sewage Treatment Plant (SEWPCC),
- West End Sewage Treatment Plant (WEWPCC).

These 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 guidance regarding implementation of HMI applications. The standard shall apply to facility HMI systems as well as local touchscreen HMIs that are specific to a piece of equipment. The document will indicate where specific standards are applicable to facility HMI systems only.

The information is presented without knowledge of the specific process implementation. It is not within the scope of this document to provide detailed implementation direction, and it will be the responsibility of the respective system designers to fully develop the HMI application details with general conformance to the concepts presented herein. This document shall not be construed as comprehensive implementation requirements or negate the requirement for professional engineering involvement. Any design and implementation 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 guide 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 guide. The expectations regarding application of this guide to new HMI systems at existing facilities must be assessed on a case-by-case basis, however general guidelines for application are presented as follows:

- All new implementations, not related to an existing facility, are expected to comply with this guide.
- All major upgrades to a facility, or a larger facility's process area, are expected to comply with this document, however in some cases compromise with the configuration of the existing facility implementation may be required.
- All minor upgrades should utilize this document as far as practical, however in some cases compromise with the implementation of the existing facility HMI system, which will be retained after an upgrade, will be required. Where these compromises are made they shall be kept to a minimum and agreed by the City.

## 1.3 Definitions

| | |
|---|---|
| A | Amperes |
| CPU | Central Processing Unit |
| CV | Control Variable (PID control) |
| FRS | Functional Requirements Specification |
| HMI | Human-Machine Interface |
| HOA | Hand - Off - Auto (switch) |
| HOR | Hand - Off - Remote (switch) |
| HP, hp | Horsepower |
| HVAC | Heating, Ventilation, and Air Conditioning |
| kW | Kilo Watts |
| I/O | Input/ Output |
| MCC | Motor Control Centre |
| PDF | Portable Document Format |
| PLC | Programmable Logic Controller |
| PV | Process Variable (PID control) |
| SI | International System (of Units) (Système International (d'Unités)) |
| SP | Setpoint Variable (PID control) |
| WSTP | Winnipeg Sewage Treatment Program |
| V | Volts |
| VFD | Variable Frequency Drive |

## 1.4 References

The following City of Winnipeg standards and guides are applicable to HMI systems:

1. Electrical Design Guide, document code 510276-0000-47ER-0001.
2. Automation Design Guide, document code 612620-0013-40ER-0001.
3. Tag Naming Standard, document code 612620-0014-40ER-0001.
4. Historical Data Retention Standard, document code 612620-0016-40ER-0001.

# 2 GRAPHIC DISPLAYS

## 2.1 General Principles

Graphic displays shall be designed and implemented in a manner that promotes operator situational awareness. Operators shall be provided with an HMI system that allows them to quickly identify and react to abnormal conditions, thereby reducing equipment downtime and improving overall facility operation.

Use the following general principles when designing and implementing HMI applications for facility desktop HMI and touchscreen HMI systems:

1. Utilize a “shades-of-grey” approach to show all process and systems, other than those in an abnormal state as shown in section 2.2.
2. Design graphic displays around the tasks and goals of the operators, rather than the sensors and equipment that produce the data.
3. Organize information in a way that allows operators to make effective decisions. Group related information together, and make important information stand out.
4. Keep users aware of the state of the system. Avoid providing too much information on any one display, but ensure that enough information is provided that operators are not blind to the facility operation.
5. Illustrate equipment on graphic displays using a flat, 2-dimensional (2D) style to prevent visual distraction from the shades-of-grey style. Use of 3-dimensional (3D) style is only accepted for pushbuttons.
6. Do not use gradients, drop shadows, or other similar graphics techniques to enhance the visual appearance of graphic displays.
7. Use the minimum amount of detail to represent equipment. Excessive detail does not promote operator understanding, but rather acts as a visual distraction.
8. Do not incorporate unnecessary animation that is distracting to operators. Examples of unnecessary animation include rotating equipment, flowing water, and flickering flames.
9. Use colour to facilitate discrimination between important information and less-important information. Important information shall be shown in red, orange, yellow, and blue. Less important information is typically shown in a shade of grey. Further information is provided in Section 2.2.
10. Use different shapes, in addition to different colours, to facilitate discrimination between important information such as alarm icons.
11. Use different shades of grey to differentiate between running and stopped equipment, opened and closed valves, and energized/de-energized cables.
12. Do not depict instruments on Dashboard displays or process mimic displays. Only display the instrument reading, along with the units of measure.
13. Use toggle buttons to allow operators to show and hide details that are useful, but clutter the display. For example, a toggle could be used to show and hide minor equipment identifiers, process control loops, and process interlocks on the graphic displays.
14. Configure all operator setting/setpoint tags with proper engineering scales to ensure operators do not input an out-of-range value.
15. Minimize the amount of typing that is required by operators by providing selection lists, radio buttons, up/down arrows, or check boxes where possible. For setpoint, control output and any other analog value input fields up/down arrow buttons shall be provided to adjust the current value in increments of 5% of input field span.

16. Ensure that sufficient space is provided between selectable display objects, and that the objects are appropriately sized, to ensure compatibility with touchscreen HMI clients. Screens are to be scalable and tested on all sized displays approved for use in the facility.

## 2.2 Colour Scheme

Process graphics are to be implemented using the *Shades of Grey* colour scheme. Equipment and process lines are shown using a shade of grey, and abnormal conditions are shown in bright colours such as red, orange, yellow, and blue.

Refer to Table 2-1 for the standard colours used within City of Winnipeg HMI systems.

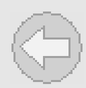
**Table 2-1: RGB Colour Reference**

| Colour | Sample | RGB Value | Typical Purpose |
|---|---|---|---|
| White | | 255, 255, 255 | Background of numeric displays, text displays, bar graphs, and gauges. |
| Grey 242 | | 242, 242, 242 | Active tab fill colour on the Header display. |
| Grey 230 | | 230, 230, 230 | Graphic Display Background,<br>Stopped Equipment Fill. |
| Grey 208 | | 208, 208, 208 | Popup Window Inactive Background |
| Grey 192 | | 192, 192, 192 | Piping, fill colour of static equipment such as tanks and vessels, object outlines for equipment that are out of service and bar graph alarm ranges. |
| Grey 160 | | 160, 160, 160 | Border colour of static equipment such as tanks and vessels,<br>Bar graph process variable. |
| Grey 154 | | 154, 154, 154 | Unused |
| Grey 128 | | 128, 128, 128 | Fill colour for Running Equipment,<br>Bar graph alarm ranges. |
| Grey 96 | | 96, 96, 96 | Process Loops,<br>Object outlines for equipment that is ready |
| Black | | 0, 0, 0 | Text, Background colour of trend displays,<br>Setpoint (SP) indicator arrows. |
| Red | | 255, 0, 0 | Priority 1 Alarms (High Priority) |
| Orange | | 255, 128, 0 | Priority 2 Alarms (Medium Priority) |
| Yellow | | 255, 255, 0 | Priority 3 Alarms (Low Priority) |
| Light Blue | | 66, 186, 255 | Abnormal States (e.g. Equipment in Manual Mode) |
| Blue | | 0, 0, 255 | Hyperlinks |

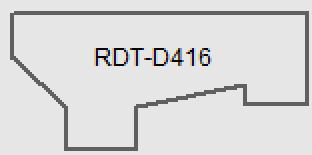
## 2.3 Standard Graphic Display Objects

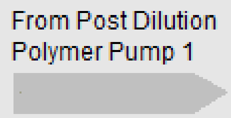
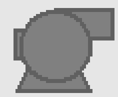
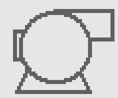
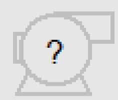
Refer to Table 2-2 for standard graphic display objects. If additional objects are required, use the same style as that shown in this standard.

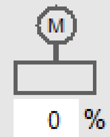
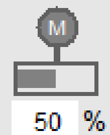
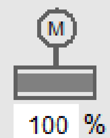
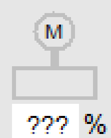
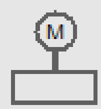
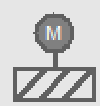
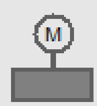
**Table 2-2: Standard Graphic Display Objects**

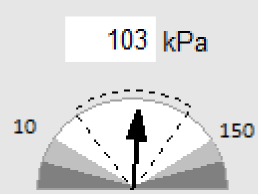
| Object | State | Colour | Sample | Notes |
|---|---|---|---|---|
| Display Background | - | Grey 230 | | |
| Primary Titles | - | Black | **Primary Title** | Arial, 14 point, bold |
| Secondary Titles | - | Black | **Secondary Title** | Arial, 12 point, bold |
| General Text | - | Black | General Text | Arial 10 point, regular |
| Medium Text | - | Black | Medium Text | Arial 9 point, regular |
| Small Text | - | Black | Small Text | Arial 8 point, regular |
| Hyperlink | - | Blue | Hyperlink | Arial 10 point, underlined |
| Display Navigation Button | - | Grey 160, Grey 208 |  | Located in the Header Display of a facility HMI application. |
| Back Button | - | Grey 160, Grey 208, White |  | Located in the Header Display of a facility HMI application. |
| Forward Button | - | Grey 160, Grey 208, White |  | Located in the Header Display of a facility HMI application. |
| Pushbutton | Enabled | System Default, Black Text | Button | Pushbuttons are to appear enabled or disabled as applicable.<br>Do not change the text on a pushbutton.<br>Disabled buttons are to appear flat. |
| | Disabled | Grey 230 Fill, Grey 160 Text, Grey 160 Border | Button | |
| Input Field | Enabled (read/write) | White Fill, Black Border | 56 % | Use *General Text* |
| | Disabled (read only) | Grey 230 Fill, Grey 160 Text, Black Border | 56 % | Use *General Text* |

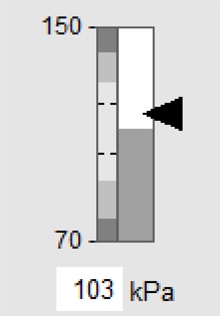
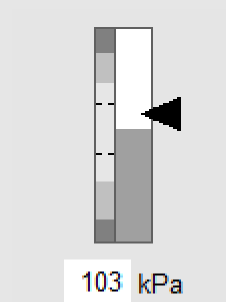
| Object | State | Colour | Sample | Notes |
|---|---|---|---|---|
| Lock Icon | Locked | Grey 160 |  | Show beside a secured object (e.g. an *Input Field*) that is locked. |
| Priority 1 Alarm Icon | Active | Red | 1 | Blink when unacknowledged, solid when acknowledged. |
| | Inactive | - | Invisible | |
| Priority 2 Alarm Icon | Active | Orange | 2 | Blink when unacknowledged, solid when acknowledged. |
| | Inactive | - | Invisible | |
| Priority 3 Alarm Icon | Active | Yellow | 3 | Blink when unacknowledged, solid when acknowledged. |
| | Inactive | - | Invisible | |
| Control Mode Icon (PLC) | Manual | Light Blue | M | Not blinking |
| | Auto | - | Invisible | |
| Control Mode Icon (Physical Switch) | Local | Light Blue | L | Not blinking. Local control mode should not have an icon (invisible) for vendor equipment that runs locally in normal operation. |
| | Hand | Light Blue | H | Not blinking |
| | Remote | - | Invisible | |
| Not Ready Icon | Not Ready | Light Blue | NR | Used if equipment is not ready to run (e.g. power is switched off).<br>Not blinking |
| | Ready | - | Invisible | |
| Alarms Disabled Icon | Alarms Disabled | Burgundy | D | Show next to equipment that has one or more alarms disabled.<br>Not blinking. |
| | No Alarms Disabled | - | Invisible | |

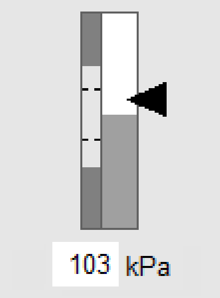
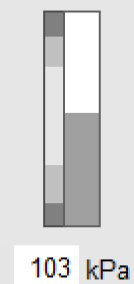
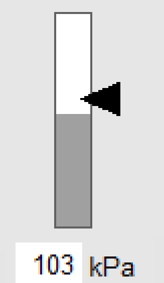
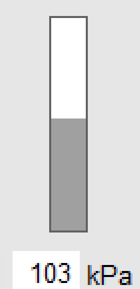
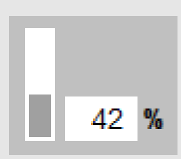
| Object | State | Colour | Sample | Notes |
|---|---|---|---|---|
| Override Icon | Override Active | Light Blue | O | Show next to an instrument or equipment that has one or more signals overridden.<br>Not blinking. |
| | No Override Active | - | Invisible | |
| Static Tank / Vessel | - | Grey 160, Grey 192, Black text |   | May adjust shape to reflect actual tank or vessel shape.<br>Do not show inner detail.<br>Show equipment identifier inside object. |
| Non-Static Equipment | Running | Grey 96, Grey 128, White text |   | Adjust the shape to reflect the shape of the equipment (typically as it is shown on the P&IDs).<br>Do not show inner detail unless required to help clarify equipment type or operation.<br>Show equipment identifier inside object. |
| | Stopped | Grey 96, Grey 230, Black text |   | |
| Large Pipe (300+ mm) or Channel | - | Grey 192, Black text | FOA | 11 Pixels in width/height.<br>Indicate Fluid Commodity Code using *Small Text*. |
| Medium Pipe (90 - 250 mm) | - | Grey 192, Black text | MP | 7 Pixels in width/height.<br>Indicate Fluid Commodity Code using *Small Text*. |
| Small Pipe (3 - 80 mm) | - | Grey 192, Black text | PD | 3 Pixels in width/height.<br>Indicate Fluid Commodity Code using *Small Text*. |
| Process Loops | - | Grey 96 | | 1 Pixel |

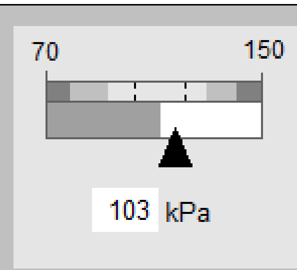
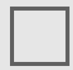
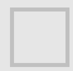
| Object | State | Colour | Sample | Notes |
|---|---|---|---|---|
| Process/Signal Continuation | - | Grey 192 |   | Provide touch link to the referenced display.<br>Use *Medium Text* (9 point). |
| Pump / Fan | Running | Grey 96, Grey 128 |  | For variable speed pumps/fans, indicate the speed in units of percent using an *Indicator* object. |
| | Stopped | Grey 96, Grey 230 |  | |
| | Unknown State | Grey 192, Black text |  | Show an *Alarm Icon* and an appropriately coloured rectangle around the object as per Table 2-3. The ? should be added to the existing graphic, Not the whole symbol shown overlaid. |
| Mixer | Running | Grey 96, Grey 128 |  | For variable speed mixers, indicate the speed in units of percent using an *Indicator* object. |
| | Stopped | Grey 192, Grey 230 |  | |
| | Unknown State | Grey 192, Black text |  | Show an *Alarm Icon* and an appropriately coloured rectangle around the object as per Table 2-3. The ? should be added to the existing graphic, Not the whole symbol shown overlaid. |

| Object | State | Colour | Sample | Notes |
|---|---|---|---|---|
| Actuated Modulating Valve or Damper | Closed | Grey 96,<br>Grey 128,<br>Grey 230 |  | The width of the bar graph inside the object reflects percentage open.<br>Show the actual position in units of % open using an *Indicator* object.<br>The actuator shown is a motor actuator. Other actuator symbols are provided below.<br>The actuator may be colour animated to reflect the running state if known. |
| | Intermediary Position | Grey 96,<br>Grey 128,<br>Grey 230 |  | |
| | Open | Grey 96,<br>Grey 128,<br>Grey 230 |  | |
| | Unknown State or Position | Grey 192,<br>Black text |  | Show an *Alarm Icon* and an appropriately coloured rectangle around the object as per Table 2-3. The ? should be added to the existing graphic, Not the whole symbol shown overlaid. |
| Actuated On/Off Valve or Damper | Closed | Grey 96,<br>Grey 230,<br>Black text |  | The actuator shown is a motor actuator. Other actuator symbols are provided below.<br>The actuator may be colour animated to reflect the running state if known. |
| | Intermediary Position | Grey 96,<br>Grey 128,<br>Grey 230,<br>White text |  | |
| | Open | Grey 96,<br>Grey 128,<br>Grey 230,<br>White text |  | |
| | Unknown State or Position | Grey 192,<br>Black text |  | Show an *Alarm Icon* and an appropriately coloured rectangle around the object as per Table 2-3. The ? should be added to the existing graphic, Not the whole symbol shown overlaid. |

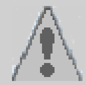
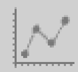
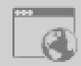
| Object | State | Colour | Sample | Notes |
|---|---|---|---|---|
| Valve Actuator - Motor | Energized (Running) | Grey 96, Grey 128, White text |  | Use in combination with a valve symbol.<br><br>See ISA 5.1 for additional actuator symbols. |
| | De-Energized (Stopped) | Grey 192, Grey 230, Black text |  | |
| | Out of Service | Grey 192, Grey 230, Black text |  | |
| Valve Actuator - Pneumatic Spring Return | Stopped or Unknown if Moving | Grey 96, Grey 128 |  | Use in combination with a valve symbol.<br><br>See ISA 5.1 for additional actuator symbols. |
| | Actuator Moving (if known) | Grey 96, Grey 230 |  | |
| | Out of Service | Grey 192, Grey 230 |  | |
| Valve Actuator - Solenoid | In Service (Energized or De-energized) | Grey 95, Grey 230, Black text |  | Use in combination with a valve symbol.<br>See ISA 5.1 for additional actuator symbols. |
| | Out of Service | Grey 192, Grey 230, Black text |  | |
| Indicator | - | White, Black | 103 kPa | Use *General Text.* Show the units outside the white box. |
| Gauge | - | Black, Grey 128, Grey 192, White |   | Setpoint or control limits indicated with dashed line(s) (as required).<br>Process reading indicated with black arrow.<br>Alarm limits indicated with darker shades of grey. |

| Object | State | Colour | Sample | Notes |
|---|---|---|---|---|
| Bar Graph, Vertical | All elements shown | Black, Grey 92, Grey 128, Grey 160, Grey 192, Grey 230, White |  | Process variable (PV) is shown inside the right-hand rectangle using Grey 160 vertical fill animation.<br>Left-hand rectangle is filled with Grey 230, and has the alarm limits and control limits overlaid on it. Low-Low and Hi-Hi alarm ranges are shown using Grey 128. Low and Hi alarm ranges are shown using Grey 192.<br>Control limits are indicated in the left-hand rectangle with black dashed lines.<br>Setpoint (SP) indicated on the right with a black arrow (triangle).<br>PV is indicated in text below the bar graph. SP indication in text is shown on the faceplate only.<br>Min/max values indicated in text to the left of the alarm limits.<br>Object outlines using Grey 92. |
| | Hi-Hi, Hi-, Low, Low-Low alarm ranges, control limits, PV, and SP are shown.<br>Min/max values are not shown. | Black, Grey 92, Grey 128, Grey 160, Grey 192, Grey 230, White |  | Alarm ranges for Low-Low, Low, Hi, and Hi-Hi are shown.<br>PV is indicated in text below the bar graph. SP indication in text is shown on a faceplate. Bar graphs should colourize when alarm thresholds are reached. Colours should be the same priority as the equipment. |

| Object | State | Colour | Sample | Notes |
|---|---|---|---|---|
| Bar Graph, Vertical | Hi, Low alarm ranges, control limits, PV, and SP are shown.<br>Hi-Hi, Low-Low alarm ranges, Min/max values are not shown. | Black, Grey 92, Grey 128, Grey 160, Grey 230, White |  | Alarm limits for Low and Hi are shown using Grey 128.<br>Alarm limits for Low-Low and Hi-Hi are not applicable. PV is indicated in text below the bar graph. SP indication in text is shown on a faceplate. |
| | Alarm ranges and PV are shown.<br>Min/max values, control limits, and SP are not shown. | Black, Grey 92, Grey 128, Grey 160, Grey 192, Grey 230, White |  | Show min/max values as required. |
| | PV and SP are shown.<br>Min/max values, alarm ranges, and control limits not shown. | Black, Grey 92, Grey 160, White |  | Show min/max values as required. |
| | Only PV is shown.<br>Min/max values, alarm ranges, control limits, and SP not shown. | Black, Grey 92, Grey 160, White |  | Show min/max values as required. |
| | The vertical bar graph is animated to reflect the tank level. | White, Grey 160, Black |  | Typically used on process mimic displays. |

| Object | State | Colour | Sample | Notes |
|---|---|---|---|---|
| Bar Graph, Horizontal | All elements shown. | Black, Grey 92, Grey 128, Grey 160, Grey 192, Grey 230, White |  | Elements may be removed as required in a similar manner as the vertical bar graph.<br>SP indication in text is only to be shown on an equipment faceplate. |
| Power Circuit Breaker | Racked in and Closed | Grey 96, Grey 128 |  | |
| | Racked in and Open | Grey 96, Grey 230 |  | Also show an *Alarm Icon* and an appropriately coloured rectangle around the object as per Table 2-3. The ? should be added to the existing graphic, Not the whole symbol shown overlaid. |
| | Racked Out, Out of Service | Grey 192 |  | |
| | Unknown State | Grey 192, Black text |  | |
| Moulded Case Circuit Breaker | Closed | Grey 128 |  | State feedback is not typically from the breaker itself. State may be inferred based on data from protection relays, power meters, or intelligent overloads, etc. |
| | Open | Grey 192 |  | Also show an *Alarm Icon* and an appropriately coloured rectangle around the object as per Table 2-3 as required. The ? should be added to the existing graphic, Not the whole symbol shown overlaid. |
| | Unknown State | Grey 192, Black text |  | |

| Object | State | Colour | Sample | Notes |
|---|---|---|---|---|
| Fuse | Energized | Grey 128 |  | State feedback is not from the fuse itself. State may be inferred based on data from protection relays, power meters, or intelligent overloads, etc. |
| | De-Energized | Grey 192 |  | Also show an *Alarm Icon* and an appropriately coloured rectangle around the object as per Table 2-3 as required. The ? should be added to the existing graphic, Not the whole symbol shown overlaid. |
| | Unknown State | Grey 192, Black text |  | |
| Bus or Cable | Energized | Grey 128 | | 3 pixels.<br>Energized state is inferred based on other data. |
| | De-Energized | Grey 192 | | 3 pixels.<br>De-energized state is inferred based on other data. |
| | - | Grey 230 | | Refer to Section 2.7.7 for information on Equipment Faceplates. |
| Equipment Faceplate Active Tab Background | - | Grey 208 | | |
| Equipment Faceplate Inactive Tab Background | - | Grey 128 | | |
| Equipment Faceplate Tab Icon, Home | | Grey 128 |  | |
| Equipment Faceplate Tab Icon, Details | - | Grey 128 |  | |
| Equipment Faceplate Tab Icon, Configuration | - | Grey 128 |  | Overlay an alarm icon if an alarm is active. |

| Object | State | Colour | Sample | Notes |
|---|---|---|---|---|
| Equipment Faceplate Tab Icon, Alarms | - | Grey 128 |  | |
| Equipment Faceplate Tab Icon, Trends | - | Grey 128 |  | |
| Equipment Faceplate Link, Webpage | - | Grey 128 |  | Provide if available from the device manufacturer. |
| Equipment Faceplate Link, Help | | |  | Provide if available from the device manufacturer. |

## 2.4 Display of Text Values

Text values on graphic displays are shown using either the *Input Field* or *Indicator* graphic objects that are listed in Table 2-2. The *Input Field* graphic object has a black border to convey the fact that it is a field that accepts input by the operator. The *Indicator* field does not have a black border, which signifies that this field does not ever accept input by the operator.

Use the fill colour of an *Input Field* object to indicate whether the field is currently accepting input by the operator. When an *Input Field* is enabled it shall be filled with white colour. When an *Input Field* is disabled it shall be filled with grey colour.

The *Input Field* object shall be linked to a discrete point or an expression to control whether it is enabled or disabled. For example, the manual speed setpoint field on an equipment faceplate for a VFD-driven pump should be linked to the auto/manual mode status to enable the field when the equipment is in manual mode.

Instrument readings on process mimic displays shall use the *Indicator* object.

## 2.5 Units of Measure

All units of measure shall be in the International System of Units (SI). One exception is that motor ratings shall be displayed in both SI units (kW) and the imperial horsepower (hp) with the horsepower rating shown in brackets.

Follow these rules when units of measure are shown on HMI systems:

1. The first letter of the unit of measure is upper-case when the name of the unit is derived from the name of a person. Examples: Volt (V), Amp (A), Watt (W),
2. The first letter of the unit of measure is lower-case when the name of the unit is not derived from the name of a person. Examples: litre (l), meter (m), gram (g), second (s), day (d) Exceptions to this would be standard units in current operations (ML(mega litre),ML/D(mega litre per day), FT(feet) etc.),
3. Units of measure are unaltered in the plural. Example: 5 cm, not 5 cms,
4. Capitalization of unit prefixes (p, n, µ, m, c, k, M, G, etc.) shall be as per standard convention,
5. Provide one space between numeric readings and the unit of measure.
6. Percentage (%) is typically used to indicate the position of valves (percent open), the speed of variable-speed motors (percent of full speed), tank level (percent full), and for other process readings that natively use percentage as the unit of measure. However, exceptions to these may be applied in specific cases. It is also permissible to indicate a process measurement in units of percent along with another unit of measure (e.g. wetwell level may be shown in units of percent and in meters). City Operations should be consulted if both are required.
7. The number of decimal places stored in the PCS should have the same number of significant digits as the source of the data. (e.g. If a flowmeter has an accuracy of 3 decimal places the display reading on the reading stored should have 3 decimal places). The number of decimal places displayed on the HMI should be a useful number to the users. If there are instances where a great number of decimal places are available, this should be discussed with the City during design.

## 2.6 Display of Equipment Status

Equipment shall be shown on graphic displays using the standard graphic symbols shown in Table 2-2. Where the status of equipment is provided to the control system, the colour and inner detail of the equipment is changed to reflect the current state, as per the following.

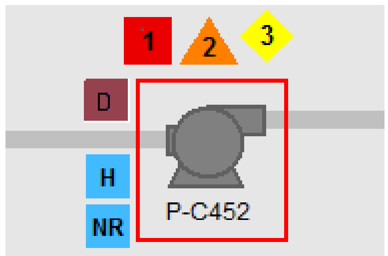
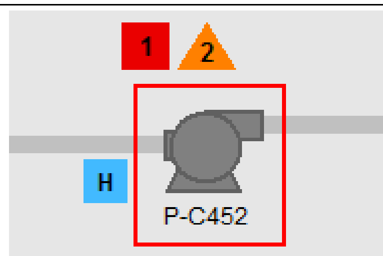
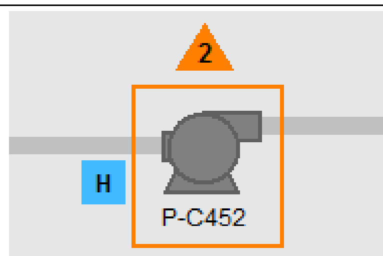
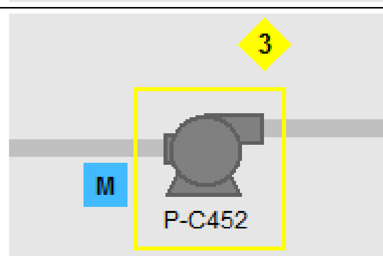
1. For equipment such as motors, pumps, fans, and mixers that have the capability of being started and stopped, colour is used to represent the equipment running status following the colour scheme in Table 2-2.
2. If the equipment, that has status reporting, is in an unknown state or position then question marks are shown on the equipment (e.g. equipment control is via an intelligent motor starter using Modbus/TCP but the communication link is down).
3. For on/off valves, fill colour is used to indicate whether the valve is opened or closed. Do not animate the fill colour of the valve based on the running status (e.g. running open or running closed) – this information can be provided on a faceplate if needed. However, if the “running” state of the actuator is known then the actuator fill colour is to be animated based on the running status. On/off valves in the open or closed states will follow the color scheme in Table 2-2. Diagonal lines are shown in the body of the valve if the valve is known to be in an intermediary position (the open limit and closed limit switches are not made). Question marks are shown on the valve if it is in an unknown position (e.g. an intelligent on/off actuator using Profibus communication, but the communication link is down).
4. On/off dampers are shown in an identical manner as on/off valves.
5. Modulating valves do not change colour. The width of the horizontal bar graph within the body of the valve changes to reflect the valve position. When the valve is fully open, the width of the horizontal bar graph shall be at its maximum. When the valve is fully closed, the width of the horizontal bar graph shall be zero. However, if the “running” state of the actuator is known then the actuator fill colour is to be animated based on the running status.
6. Modulating dampers are shown in an identical manner as modulating valves.
7. For *Indicator objects*, indicate three question marks inside the indicator if the value is unknown as a result of some failure in the system (e.g. a communication failure).
8. “Out of Service” state should be used when the piece of equipment is locked out or physically cannot operate.
9. “Not Ready” state should be used when the piece of equipment cannot be run due to a physical or programming interlock.
10. The manual-only equipment that are on the current treatment plants HMI graphics (e.g. S+ HMI system) should be migrated to the PCS HMI for DCS migration projects. For HMI graphics that will be developed for other new and upgrade projects, the display of manual-only equipment will be subject to City review/approval.

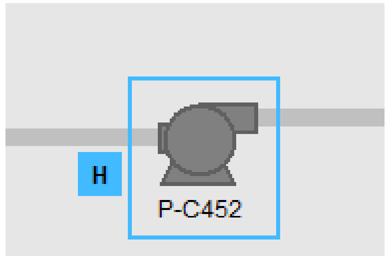
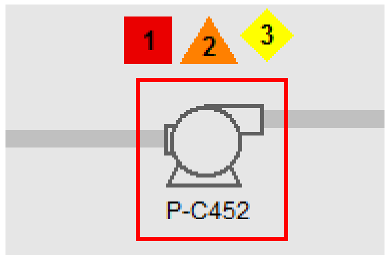
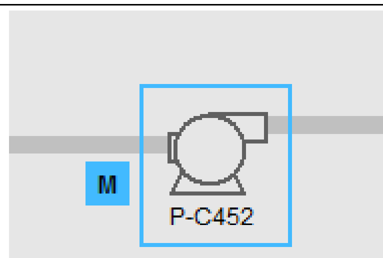
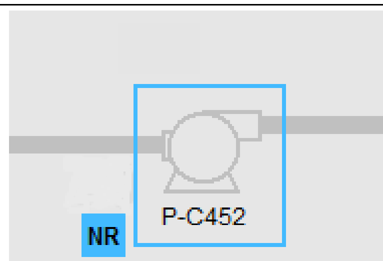
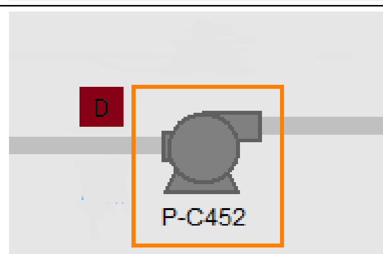
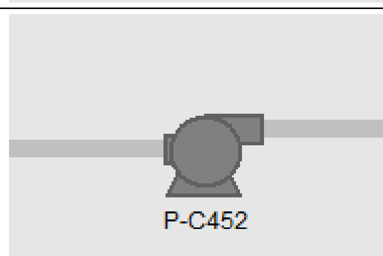
The applicable alarm and abnormal condition icons, as per Table 2-2, shall be shown adjacent to each piece of equipment that have alarms or abnormal states. Standard icons are provided for each alarm priority level, and for indicating the equipment is in hand mode, manual mode, not ready, has alarms disabled, or a signal is overridden. Use visibility animation to show and hide these icons depending on the state of the equipment. Some operating modes are mutually exclusive and therefore the icons may overlap each-another since they will not both be shown at the same time. For example, the ‘Hand’ control mode is mutually exclusive with the ‘Manual’ PLC mode, therefore the “H” and “M” icons may overlap. The icons should be located consistently throughout the screens. For example, the H/M icon should remain at the location as shown in Table 2-3 throughout the HMI screens.

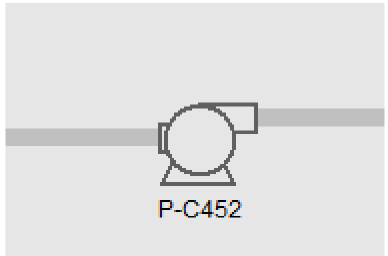
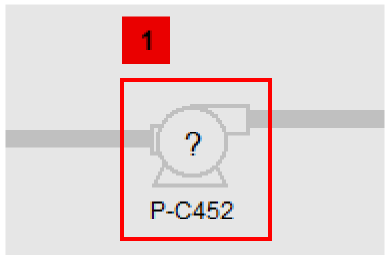
When an alarm or control mode flag icon for an equipment appears visible, a rectangle of the same colour as the icon shall be shown around the equipment. The rectangle is coloured the same colour as the highest priority alarm or abnormal condition to handle cases where multiple alarms of different priority levels may be active at the same time. If no alarms are active but a control mode icon is shown, show a light blue rectangle around the equipment. There should be a defined border around the devices to ensure the status does not cover any device detail text and will ensure consistency throughout process mimics. At no time should the rectangle cover other pieces of information on or around the graphic.

Refer to the sample figures in Table 2-3 for the standard method of displaying equipment status.

**Table 2-3: Display of Equipment Status**

| State | Sample | Notes |
|---|---|---|
| All symbols shown<br>(in development environment) |  | All symbols are organized around the equipment in close proximity and fixed in their positions.<br>The "Hand" (H) icon overlaps the "Manual" (M) icon as these are mutually exclusive. As such, the "Manual" (M) icon is unseen. The same would apply if "Local" (L) was needed in certain cases instead of Manual. |
| Equipment Running in Hand with a Priority 1 and Priority 2 alarm. |  | The rectangle is shown in red since the Priority 1 alarm condition supersedes both the Priority 2 alarm condition and the "Hand" abnormal condition. |
| Equipment Running in Hand with Priority 2 alarm. |  | The rectangle is shown in orange since the alarm condition supersedes the abnormal condition (Hand). |
| Equipment Running in Manual mode with a Priority 3 alarm. |  | The rectangle is shown in yellow colour since the alarm condition supersedes the abnormal condition (Manual). |

| State | Sample | Notes |
|---|---|---|
| Equipment Running in Hand mode with no alarms. |  | The rectangle is shown in blue because there are no active alarms. |
| Equipment stopped with Priority 1, Priority 2, and Priority 3 alarms active. |  | The rectangle is shown in red since the Priority 1 alarm condition supersedes the Priority 2 and Priority 3 alarms. |
| Equipment stopped in Manual mode with no alarms. |  | The rectangle is shown in blue because there are no active alarms and blue matches the Manual (M) icon. |
| Equipment Not Ready and stopped with no alarms. |  | The rectangle is shown in blue because there are no active alarms and blue matches the Not Ready (NR) icon. |
| Equipment running in remote with one or more disabled alarms. |  | Disabled Alarms (D) icon.<br>The colour of the rectangle should follow the highest priority disabled alarm. In this case the highest disabled alarm is a Priority 2. |
| Equipment running in Remote with no alarms. |  | No rectangle is shown around the equipment since there are no alarms. |

| State | Sample | Notes |
| --- | --- | --- |
| Equipment stopped in Remote with no alarms. |  | No rectangle is shown around the equipment since there are no alarms. |
| Unknown State – Communication Failure between PLC and equipment |  | A question mark is shown inside the equipment to reflect that the equipment state is unknown.<br>A Priority 1 alarm is shown as a result of the communication failure; however, the priority level may vary depending on the equipment. |

## 2.7 Display Types

### 2.7.1 General

HMI applications will include several types of displays for viewing various levels of detail, and for operator tasks such as viewing trends and alarms. For multiple screen support, the functionality of each screen will be the same. Displays are generally broken down into the following categories:

1. Header/Footer Displays
2. Navigation Displays
3. Dashboard Displays
4. Process Mimic Displays
5. Equipment Detail Displays
6. Equipment Faceplates (Popups)
7. Trend Displays
8. Alarm Summary Displays
9. Historical Event Displays

Where a header or footer display is provided in an HMI system, the term “full-screen display” refers to a display that occupies all of the remaining screen space that is not already occupied by the header or footer. On system start-up, the system shall display the Facility Layout Overview page.

Each of these display types are discussed in the following sections.

### 2.7.2 Header/Footer Displays

A header or footer display shall be provided on each HMI system for locating elements that are common to all displays. The header or footer will always be present on the screen, and not covered or replaced by other displays.

For facility HMI systems, a header display shall be provided which contains the following:

1. The facility name (e.g. NEWPCC, SEWPCC, or WEWPCC) to convey to operators which site they are operating, which is useful for remote applications (e.g. control of SEWPCC from NEWPCC),
2. A Display Navigation button (icon) that links to the Facility Layout Overview page,
3. Log In/Out button,
4. Button to close all/unpinned faceplates,
5. Button to open an on-fly process analysis trend with the ability to add signals manually,
6. Button to launch historical events (including historical alarms, operator actions, user log in/log out information, and PCS system alarms,
7. Back and forward buttons (icons) for display navigationaccording to navigation history,
8. Separate back, forward, and up buttons to navigate according to navigation hierarchy,
9. A print button to print current active display.
10. A display page open button, which will allow operator to choose a display to open with option to replace the existing open display or open as a new tab.

11. The list of the buttons and sequence of the buttons shall be configurable without editing the template,
12. If possible, a breadcrumb trail showing the path to the current display within the display hierarchy,
13. The currently logged in user,
14. A row of tabs listing the open full-screen displays.

For facility HMI systems, a footer display shall be provided which contains the following:

- A table of alarms by process area. The process area shall start with All, which encompass the whole facility. The process area shall end with PCS system status.
- The number of process areas and sequence of the process area shall be configurable without modifying template,
- An alarm list that shows the three most recent alarms at the facility,
- The present date and time, and

A sample footer for a wastewater treatment facility HMI is shown in Figure 2-1.


**Figure 2-1: Sample Facility HMI Footer**

The breadcrumb trail indicates the path to the current full-screen display within the display hierarchy, and allows operators to navigate to other displays. Levels within the hierarchy are separated by right-hand arrows. Clicking an arrow opens a list of all displays at that level in the hierarchy, and clicking on a display in the list shall open the display. This is similar to the breadcrumb navigation system of Windows Explorer (File Explorer) in Windows 7 and above.

The table of alarms lists the quantity of unacknowledged alarms and acknowledged alarms in each process area. Coloured triangles are used to indicate the priority level of the highest priority alarm. Clicking on a column (process area) within the table of alarms brings the operator to an Active Alarm Display that lists only the alarms in that process area. If no alarms are active in a specific process area, a hyphen rather than a zero (“0”) shall be shown.

The alarm list shows the three most recent alarms at the facility, along with the date/time that the alarm occurred, alarm tag name, alarm tag description, alarm status, and the associated alarm icons (without the numbers “1”, “2”, or “3” inside the icons). Clicking on the alarm list brings the operator to a full-screen Active Alarm display that lists all of the active alarms for the facility. In the three-line alarm list, unacknowledged alarms are shown using bold and blinking text and acknowledged alarms are shown using non-bold and non-blinking text. The state of the alarms (e.g. “ON” or “OFF”) are shown at the far right of the alarm list.

Along the bottom of the header is tab bar that may be used to immediately go to any open display. When an operator opens a new display, a new tab is added to the tab bar. New tabs are added to the right-hand side of the list of tabs. The active tab is shown using Grey 242 fill with black text, and non-active tabs are shown using Grey 208 fill and Grey 128 text. Clicking an in-active tab brings the associated display to the foreground. A configurable maximum number of tabs can be opened. This is only to be configured at the Administrator level. When the maximum number of tabs is reached, the most left tab will be closed automatically before open new tab. The initial maximum number of tabs is 4.

The background (fill) colour of the items the header display (except for the active tab) shall be Grey 208.

Regarding touchscreen HMIs used for local equipment control, a footer display shall be provided which contains a button bar for display navigation, an indication of the number of unacknowledged and acknowledged alarms, the current user, and the present date and time, as applicable. Header displays are generally not provided on local touchscreen HMIs.

Additional information or controls that are common to all full-screen displays may be added to header/footer displays as required and agreed upon by the City.

### 2.7.3 Navigation Displays

Navigation displays are provided within facility HMI applications as the primary means for display navigation, and to open external applications and documentation used by operators. Navigation displays are implemented as full-screen displays.

Facility Layout Overview is the highest hierarchy navigation display, which is the first display when the system starts and it can always be accessed by using the Display Navigation button described in item 2 of section 2.7.2

Navigation displays contain links to other full-screen displays in the HMI application. The display shall have previous and next display configured for the same hierarchy, and parent page be configured for higher hierarchy. Links shall be provided to trends associated to key variables that are on the display. Trend display shall be opened in a new trend tab if it is the first trend tab or it shall replace an existing trend tab. In case maximum number of tabs is reached, the tab on the most left is closed before the new tab is opened. Equipment faceplates or other popup displays are not typically listed on navigation displays.

For each process flow path, a display link is implemented using a rectangular arrow following the process flow that contains a description of the item it links to. The rectangles are sufficiently sized to ensure compatibility with touchscreen HMI clients. The borders of the rectangles are colour coded based on the type of display or item they link to. Use blue colour for Dashboard displays, green for process mimic displays, and purple for equipment detail displays. Other colours may be used as required, but do not use alarm colours (red, orange, and yellow).

Design and implement navigation displays such that the operator is able to access any full-screen display with ideally three (3) or fewer clicks. Note that clicking on the Display Navigation button in the header counts as one click, leaving two more clicks on the navigation display to open the desired item.

The display shall be embedded with a hidden hot key command (Esc), which will be linked to a display at the higher hierarchy.

A sample Facility Overview Page is shown in Figure 2-2.

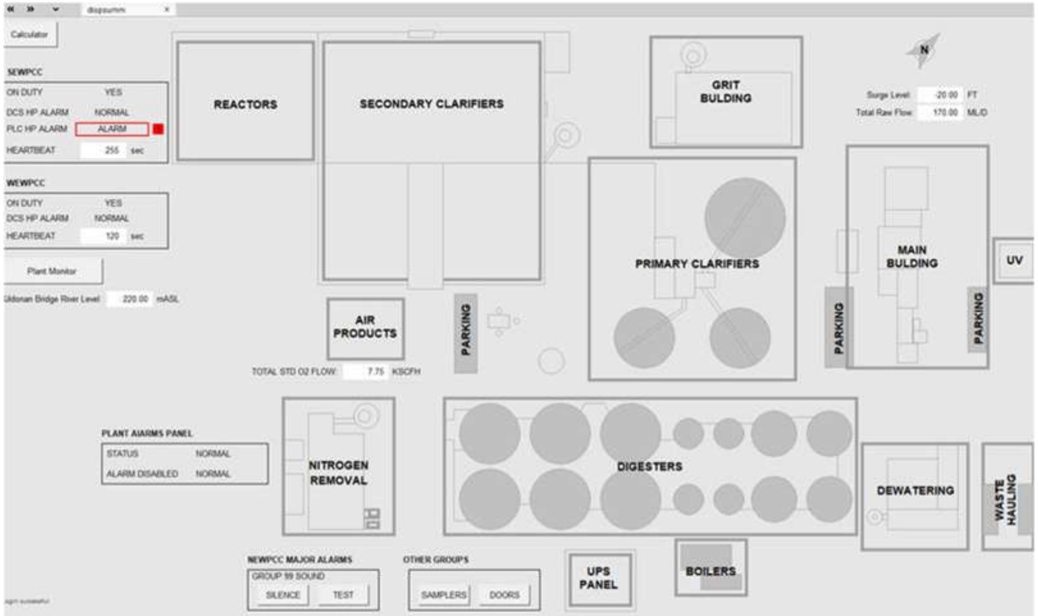



**Figure 2-2: Sample Facility Overview Page**

*Notes:*

1. *Process area links (rectangles with a grey outline) are provided. These are used to show the display links for each process area. This should be provided before any area specific design to ensure proper implementation.*
2. *A typical navigation screen for a major process area would contain more Detail Displays.*

### 2.7.4 Dashboard Displays

A Dashboard display shows an overview of a facility, process area, or one or more process trains and appears like a dashboard or instrument panel.

A facility HMI system will incorporate numerous dashboard displays, one for the entire facility, one for each small process area, and multiple dashboard screens as required for larger process areas. The area dashboard displays shall be accessible via a page link on facility/process area overview display.
A local touchscreen HMI will typically have a single dashboard display, but additional dashboard displays may be provided if required.

The content and organization of dashboard displays shall be focused on the operators' tasks and goals. The display should not appear like a process mimic, but rather a dashboard or instrument panel. Show only the important operating modes and major process readings such as major flows, levels, and analytical readings. Check with Operations for requirements.

Dashboard displays should not be designed to represent the physical configuration of the facility or process. They should generally be organized left to right, top to bottom, in terms of major process flow.

Group related information together. In some cases, it may be useful to group together all elements associated with a single piece of equipment. In other cases, it may be useful to group together one element from multiple pieces of equipment for the sake of comparison.

Important numerical information shall be presented inside a gauge or bar graph to give the operator a sense of where the reading lies with respect to the control and alarm limits. Indicate control and alarm limits on gauges and bar graphs wherever possible.

If a fraction of a reading, difference between two readings, or an average of two readings is important to operators, provide the information on the display rather than making operators do the mental arithmetic. Note that the computation of these shall be in the PLC, and the HMI is used for display only.

Where practical, incorporate small trends into Dashboard displays to allow operators to anticipate future alarm conditions, and react before the alarm occurs. The trends should have minimal detail, showing only the applicable setpoint, control limits, and alarm limits, and do not need to be fully-functional in terms of zooming and scrolling back in time. Link these small trends to full-screen trend displays that have the complete functionality.

A small process flow diagram should be included on dashboard displays where applicable. A process flow diagram is a high-level flow diagram without all the detail that would be shown on a process mimic display. The process flow diagram helps operators understand the process and may also be used as an alternative means to navigate between displays. The process flow diagram may appear like a typical block diagram, or the standard equipment symbols of Table 2-2 may be used. Where the standard equipment symbols are used, they may be reduced in size.

Indicate alarms and abnormal conditions using the standard icons listed in Table 2-2. In addition, a coloured rectangle shall be shown around the equipment, as per Section 2.6.

A sample dashboard display for an intake wetwell and the raw sewage pumps at a wastewater treatment facility is shown in Figure 2-3.

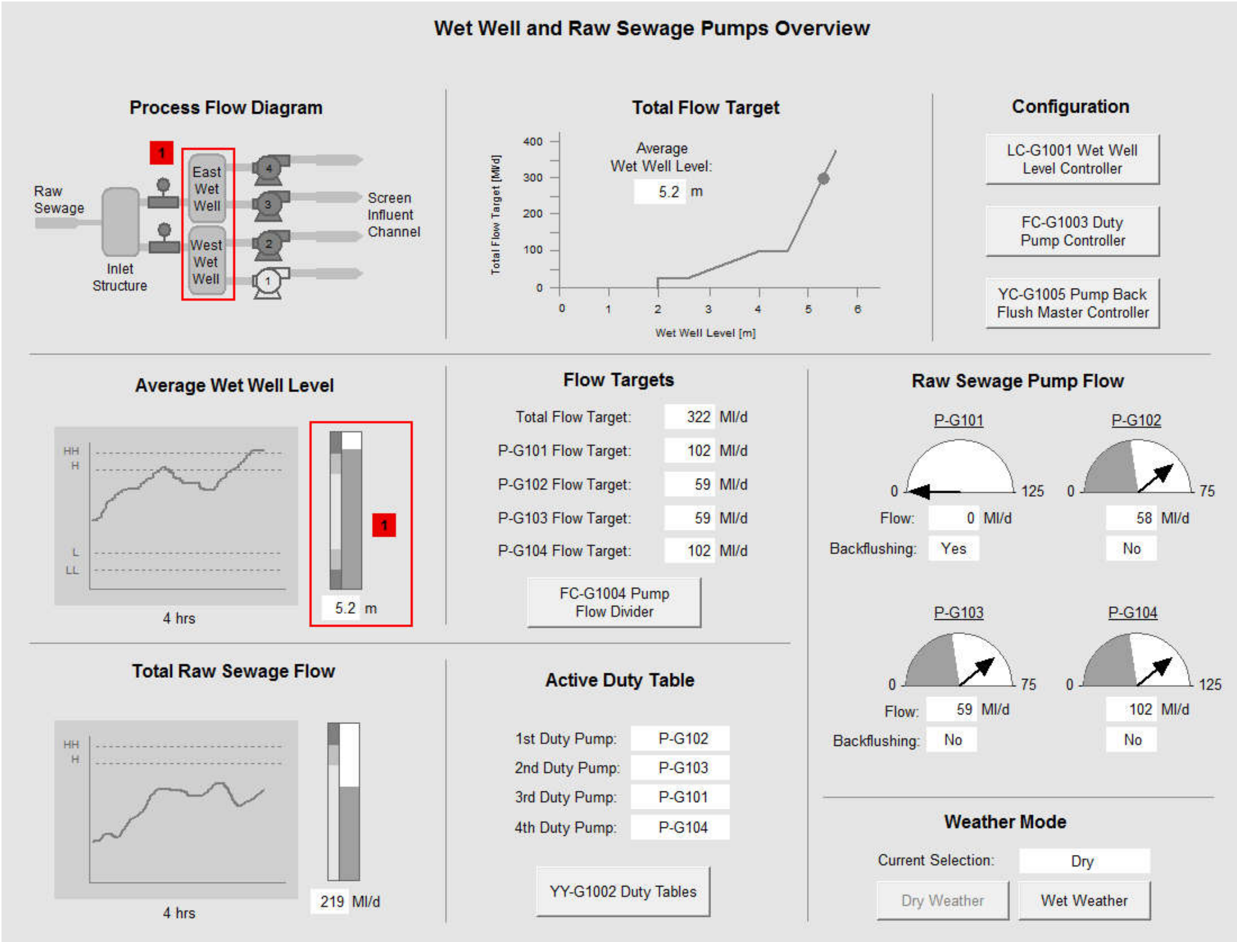



**Figure 2-3: Sample Dashboard Display – Wet Well and Raw Sewage Pumps**

*Notes:*

1. *This Dashboard display is applicable to a portion of the Headworks Area at a wastewater treatment facility. Additional Dashboard displays would be provided for the remaining equipment in the Headworks Area.*
2. *Small trends are incorporated into the display to show the wet well level. This allows operators to predict future low- or high-level conditions, and react before they occur. These trends shouldn't be used if they are not easily visible to the operator.*
3. *Bar graphs and gauges are used to indicate process readings and are accompanied by text displays to give the exact value.*
4. *Text displays (without bar graphs and gauges) are used for information that does not change frequently and does not have alarm limits, such as the pump duty assignments.*
5. *A Priority 1 high-high level alarm associated with the Average Wet Well Level is shown. The wet wells in the process flow diagram and the wet well level bar graph are highlighted with a red rectangle, which matches the Priority 1 alarm colour.*
6. *Only the important information is shown on the display. Setpoints and operating modes that are infrequently changed are accessible via equipment faceplates. Pushbuttons are provided to open the equipment faceplates where not available by clicking on the equipment.*

### 2.7.5 Process Mimic Displays

Process mimic displays are full-screen displays that show a mimic of the process, similar to a Single Line flow diagram but without unnecessary detail as shown on Figure 2-4. The display shall have previous and next display configured for the same hierarchy, and parent page shall be configured for higher hierarchy. The design should ensure that all processes are incorporated into the least number of screens and space.

Links shall be provided to trends the associated key variables that are on the display. Trend display shall be opened in a new trend tab if it is the first trend tab or it shall replace an existing trend tab. In case maximum number of tabs is reached, the tab on the most left is closed before the new tab is opened.

Equipment that is not controlled or monitored by the PLC system shall be omitted from the process mimic. Examples of such equipment include hand valves, strainers, flex couplings, reducers, pressure regulators, and back-flow preventers. Instruments, PLC I/O, and PLC functions that are typically shown on P&IDs are also omitted from process mimic displays, though instrument readings are still shown.

Instrument readings are shown using the *Indicator* graphic symbol (see Table 2-2). Instrument readings for tanks are shown inside the tank, whereas readings for instruments installed within pipes are shown adjacent to the pipe. Provide touch animation on instrument readings as required to open the associated instrument faceplate display.

Where a particular piece of equipment is outfitted with numerous sensors, it may be appropriate to display only the important readings and show the other readings on an equipment detail display or equipment faceplate.

Equipment such as pumps, motors, mixers, and valves that have state feedback to the PLC shall be colour animated, using shades of grey, to reflect their state. Refer to Table 2-2 for standard graphic display objects. Note that Table 2-2 only lists typical objects and additional objects may be created as required and are subject to review by the City.

Pipes are shown using Grey 192. Pipes are shown in three different widths (see Table 2-2) to reflect the sizes (diameters) of pipes in the field. Pipes should show type, eg. FOA (Foul Air), not size in the description.

Tanks and other static equipment are shown using the colours in Table 2-2.

Indicate alarms and abnormal conditions using the standard icons listed in Table 2-2. In addition, a coloured rectangle shall be shown around the equipment or instrument reading, as per Section 2.6.

Display equipment identifiers for major and minor pieces of equipment. Identifiers for tanks should be shown inside the tank wherever possible. For equipment other than tanks, the identifier should be located below the equipment. Use *Medium Text* for major equipment identifiers (Equipment Tag) and *Small Text* (Equipment Description) for minor equipment identifiers see Table 2-2 for the font type and point size.

Provide a means to navigate across the process mimic displays, such as with pushbuttons or with touch links on process line continuation symbols. Provide pushbuttons to navigate up to the associated dashboard display as required. The displays should be organized in a logical manner grouped by process area and area flow eg. Primary process area precedes Secondary process area.

When a value (analog/digital) is displayed on HMI, the tag name associated with the value should be easily accessible to user via context menu (brings up the tag definition), tooltip, or other means.

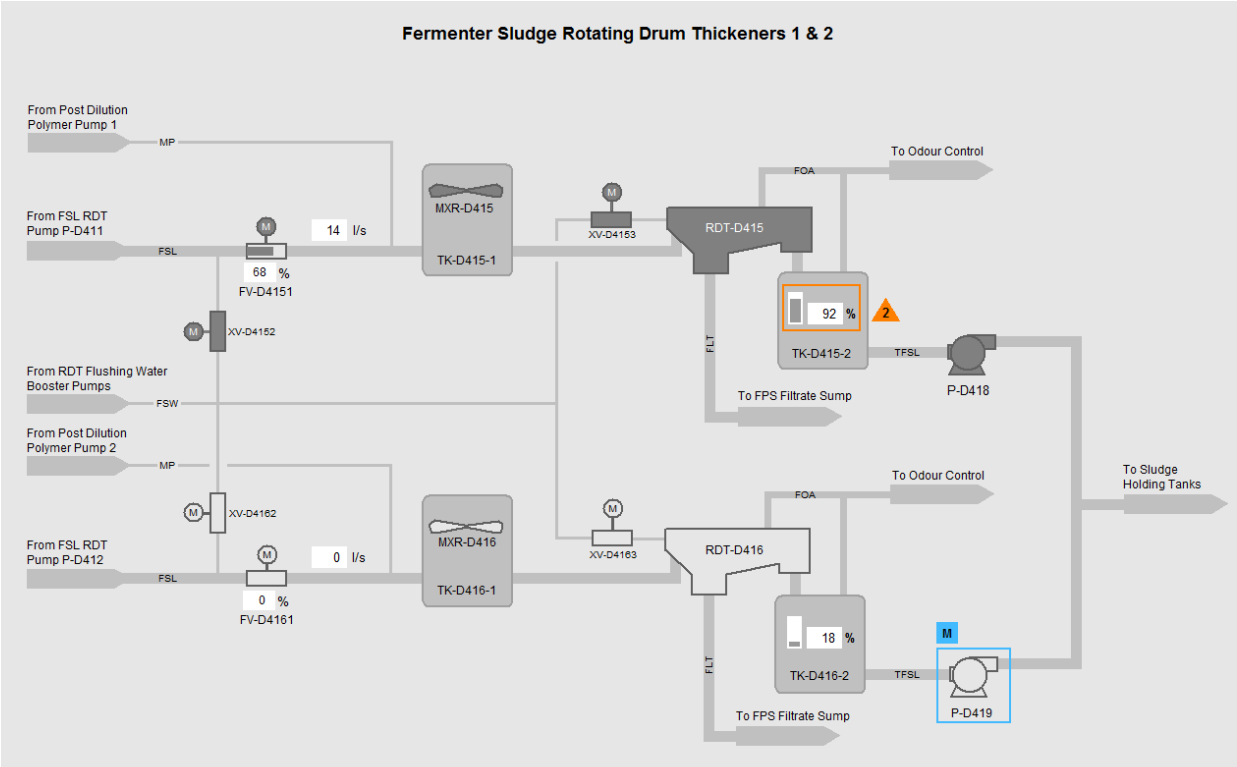



**Figure 2-4: Sample Process Mimic Display**

*Notes:*

1. *A high-level alarm in tank TK-D415-2 is shown with a Priority 2 Alarm. An orange rectangle is shown around the level indicator.*
2. *Mixers MXR-D415 and MXR-D416 are shown as running and stopped, respectively.*
3. *Rotating drum thickeners RDT-D415 and RDT-D416 are shown as running and stopped, respectively.*
4. *Pump D-D419 is in Manual mode, therefore a blue rectangle is shown around the equipment.*
5. *The width of the pipes shown is indicative of the pipe size in the field, as per* Table 2-2*.*

## 2.7.6 Detail Displays

### 2.7.6.1 General

Detail displays shall have previous and next display configured for the same hierarchy, and parent page shall be configured for higher hierarchy. Links shall be provided to trends the associated key variables that are on the display. Trend display shall be opened in a new trend tab if it is the first trend tab or it shall replace an existing trend tab. In case maximum number of tabs is reached, the tab on the most left is closed before the new tab is opened. Detail displays are typically provided for equipment that has many status and control points that cannot fit on an equipment faceplate (popup). As such, equipment detail displays are not usually provided for pieces of equipment that have an equipment faceplate, such as a motor or valve.

Detail displays can be implemented in several ways, depending on the type of information to be displayed. Several types of detail displays are defined below.

### 2.7.6.2 Equipment Detail Displays

Sophisticated pieces of equipment typically require a dedicated full-screen display to show all the equipment information and HMI controls. While process mimic displays typically only show high-level information, equipment detail displays show most or all of the information associated with the equipment.

The exact equipment shape and inner detail is omitted from process mimic displays but may be shown on equipment detail displays if required. This may help convey instrument locations, etc. Process mimic pages should be based on the P&ID drawings.

The typical information to present on equipment detail displays includes equipment operating modes, status information, operating statistics, and instrument readings. Pushbuttons, numeric input fields, and sliders are provided to facilitate control and setpoint adjustment. A small process or equipment mimic diagram may be provided as required to assist operators, and may also be used for navigation.

Pushbuttons may be provided to open popup windows that contain additional information and controls that would not fit on the equipment detail display. However, if the information is critical to operators it should be shown on the equipment detail display rather than a popup.

A sample equipment detail display for a UV reactor is shown in Figure 2-5 below.

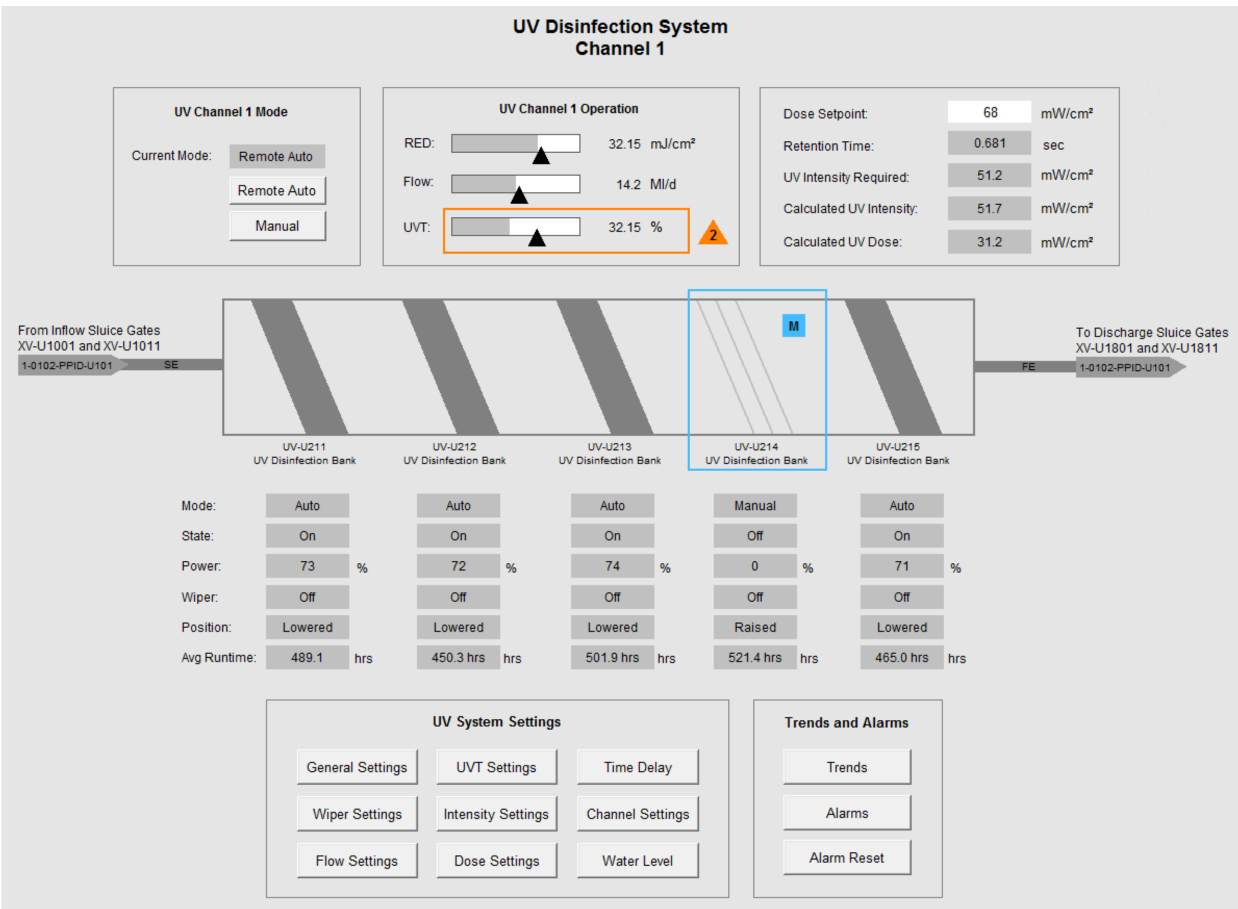



**Figure 2-5: Sample Equipment Detail Display – UV Reactor**

*Notes:*

1. *The most important operating modes and status information are provided at the top of the display.*

2. *The equipment is shown with some inner detail to reflect the equipment in the field.*
3. *Pushbuttons are provided at the bottom of the display to open popup windows with additional information and controls.*
4. *A Priority 2 alarm is shown next to the UVT bar graph. The bar graph is also outlined with an orange rectangle.*
5. *UV Disinfection Bank UV-U214 is in manual mode and therefore a blue rectangle is shown around this bank.*

### 2.7.6.3 Sequencer Detail Displays

Where equipment is controlled via sequencing logic in the PLC system, the details of the sequence shall be provided on a sequencer display. The display shall have previous and next display configured for the same hierarchy, and parent page be configured for higher hierarchy. Links shall be provided to trends the associated key variables that are on the display. Trend display shall be opened in a new trend tab if it is the first trend tab or it shall replace an existing trend tab. In case maximum number of tabs is reached, the tab on the most left is closed before the new tab is opened.

The following is applicable to process displays associated with sequencing logic.

Show all states of the sequence on the left side of the display. Each state is represented with a rectangle containing the state number at the top and a brief description within. The state rectangles shall normally be grey, and turn a different shade of grey when the associated state is active. Arrows are used to illustrate the normal progression through the sequence.

Abnormal procession through sequence is required, Arrows or other methods may be used to define the state where sequence stops (e.g. Fault conditions)

Clicking on a specific state will show information regarding that state on the right side of the display. Additionally, when the sequencing logic in the PLC transitions from one state to the next, the information area shall be automatically updated to show the information related to the new state.

The information area on the right side of the screen contains a brief description of the state, the actions that will be taken in that state, and the conditions required to progress to the next state(s). In the list of actions, list all actions that are performed by the sequencer, such as starting/stopping of equipment. Note that actions are the commands generated by the sequencer, and are not based on feedback from the field. In the list of conditions to transition to the next state, list all the conditions that are required to progress to the next state, such as seeing that equipment is currently running/stopped, seeing that equipment is running/stopped for a period of time, or waiting for a certain process condition. Provide circular indicator lights beside each action and condition to indicate whether they have been satisfied. The indicator light shall be grey if not satisfied, and green if satisfied. Alarm conditions are shown using a red, orange, or yellow indicator lights, coloured based on the priority of the alarm.

Provide hyperlinks to major equipment faceplates inside the information area using blue underlined text. Operators may use these hyperlinks to view equipment faceplates or equipment detail displays to reset equipment-specific alarms, should they occur.

Near the bottom of the information area, indicate the current status of the sequencer, such as “Running”, “Waiting”, “Faulted”. This status information shall be customized for the associated sequencer.

Some sequencers have maximum step timers that generate an alarm if the sequencer becomes stuck. Where maximum step timers are used, show the elapsed time and maximum allowable time for each state in the sequence at the bottom of the information area.

Pushbuttons are provided at the bottom of the display to pause, resume, and reset the operation of the sequence. These buttons may not always be required, and shall be customized for the applicable sequencer.

A sample sequencing display for a high-rate clarifier is shown in Figure 2-6.

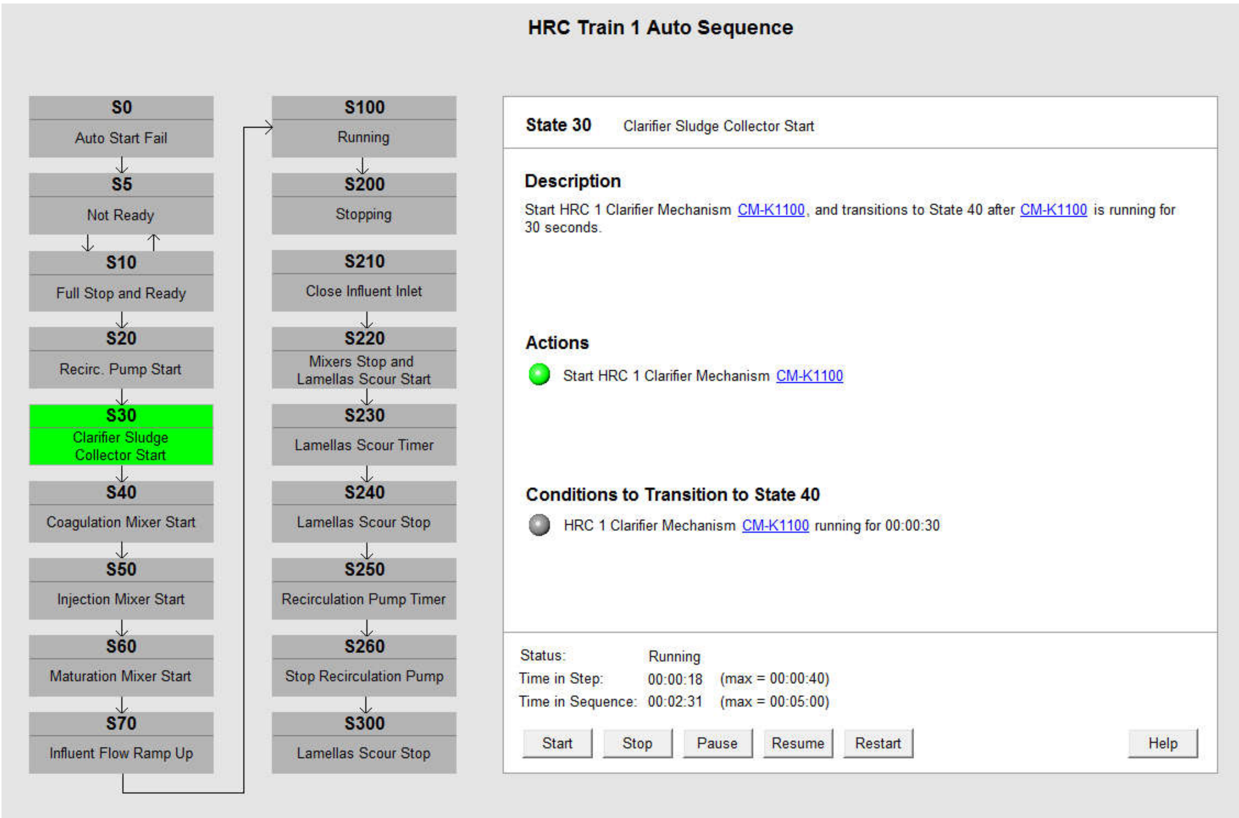



**Figure 2-6: Sample Process Detail Display for a Sequencer**

*Notes:*

1. *State 30 is the active state and is shown in green colour.*
2. *Information regarding State 30 is shown on the right side of the screen.*
3. *Hyperlinks to the CM-K1100 equipment faceplate are provided in blue, underlined text.*
4. *In the list of Actions, the HRC 1 clarifier mechanism has been commanded to start, which is represented using a green indicator light.*
5. *If the list of conditions, the sequencer has not seen the clarifier mechanism running for 30 seconds, therefore the indicator light is still grey.*

#### 2.7.6.4 Electrical Single Line Detail Displays

Single line diagrams are provided in the facility HMI system to view the operation of the electrical system. The electrical system should be shown down to the lowest monitored level, which at minimum shall include the 600V buses.

For switchgear that contains power meters or feeder protection relays, provide the voltage and ampere readings from these devices on the detail display. Clicking these will open the associated power meter or protection relay equipment faceplate (popup).

Electrical equipment detail displays are also shown using the “shades of grey” colour scheme. Energized equipment is shown in darker grey, and de-energized equipment is shown in lighter grey. If the state of the equipment is unknown, it is shown in light grey with a question mark. Provide a legend at the top corner for all electrical single line displays.

Refer to Table 2-1 and Table 2-2 for the specific colours and symbology used on electrical single line detail displays.

Avoid showing transformer kVA or MVA ratings, circuit breaker ampere ratings, or fuse ampere ratings as these details are not required for normal operations.

A sample electrical equipment detail display is shown in Figure 2-7 below.

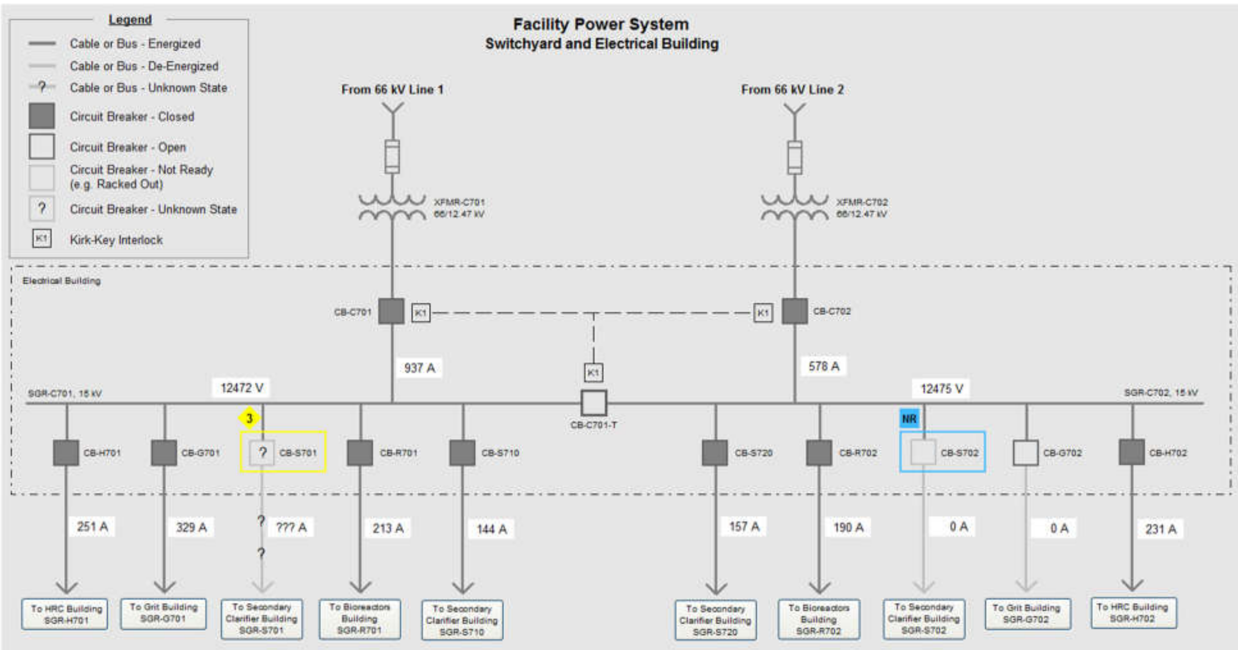



**Figure 2-7: Sample Electrical Single Line Detail Display**

*Notes:*

1. *Circuit breaker CB-S701 status is unknown and therefore the breaker and downstream cable are shown in the unknown state.*
2. *Circuit breaker CB-S702 is shown as “Not Ready” (e.g. racked out).*
3. *Circuit breakers CB-C701-T and CB-G702 are shown in the open state.*

### 2.7.7 Equipment Faceplates

Equipment faceplates are provided for individual instruments and equipment such as pumps, fans, and valves to view equipment status and facilitate control. Some control system functions, such as PID controllers, will also require a faceplate for viewing the process value and control value.

Equipment faceplates may be sized as required to accommodate the required status and control objects. If a particular faceplate needs to be larger than approximately 25% of the display, then a secondary screen to support details should be used.

The faceplate information should be populated by the associated equipment definition. No duplicated data entry or manual entry should be required.

The input to the genie should not be duplicated information already exist in the equipment definition. The input information entered on the genie should be the minimum required.

If possible, configure equipment faceplates such that they can be pinned or unpinned. When pinned, the equipment faceplate shall not automatically close when the operator navigates to a new full-screen display. However, when un-pinned the faceplates do automatically close when navigating to a new full-screen display. This allows multiple equipment faceplates to be open at a time for simultaneous control and monitoring. There should be a standard location where the equipment faceplates are located when pinned.

Provide a title at the top of the faceplate containing the equipment tag based on the P&IDs and a description of the equipment. Use the *Primary Title* font style for the equipment identifier and the *Secondary Title* font style for the equipment description. Refer to Table 2-2 for standard font styles.

Provide a series of tabbed pages on equipment faceplates for grouping common elements. Refer to Table 2-2 for standard tab icons. The following tabs are typically provided, but may be customized to suit the equipment:

- Home: primary tab for viewing status information and for manual control.
- Details: tab for viewing detailed equipment status information, alarm setpoints, and for adjusting equipment control setpoints (where desired by the City).
- Alarms: filtered alarm list, showing only those alarms that are applicable to the equipment.

When an alarm is in active status a border should display on the alarm status text field. The border colour will be based according to the alarm priority colour.

The specific content on each tabbed page is dependent on the type of equipment the faceplate is associated with, and will be detailed in the equipment class definitions of the project's Enhanced Process Control Narratives. Faceplates should be standardized for each type. Typical equipment faceplate content for various types of equipment is provided in Table 2-4.

**Table 2-4: Typical Equipment Faceplate Status and Controls Information**

| Equipment | Tabbed Page | Typical Content |
|---|---|---|
| Motors (FVNR) | Home | • Ready indication<br>• Running indication<br>• Interlocked indication<br>• Local/Remote mode indication<br>• Auto/Manual mode indication<br>• Auto/Manual mode pushbuttons<br>• Manual mode Start/Stop pushbuttons<br>• Fault indication<br>• Alarm Reset pushbutton |
| | Details | • Contactor Delay setting indication<br>• Start Time Delay after Power On setting indication |

| Equipment | Tabbed Page | Typical Content |
|---|---|---|
| | | • Runtime Totalizer<br>• Pushbutton to reset Runtime Totalizer<br>• Elapsed time of current run<br>• Elapsed time since last run |
| | Alarms | • Fail<br>• Fault |
| Motors (VFD) | Home | Typical content for Motors (FVNR) plus:<br>• Motor Speed (feedback) indication<br>• Manual Motor Speed setting |
| | Details | Typical content for Motors (FVNR) |
| | Alarms | • Fail<br>• Fault |
| Pumps | Home | Typical content for Motors (FVNR or VFD) plus:<br>• Low Flow status<br>• Low Seal Water Pressure status |
| | Details | Typical content for Motors (FVNR or VFD) plus:<br>• Low Flow alarm delay setting indication<br>• Low Seal Water Pressure alarm delay setting indication |
| | Alarms | • Fail<br>• Fault |
| Valves | Home | • Power Fail Indication<br>• Interlocked indication<br>• Local/Remote mode indication<br>• Auto/Manual mode indication<br>• Auto/Manual mode pushbuttons<br>• Position command (Open / Close, or % Open)<br>• Position indication (Open / Closed, or % Open)<br>• Manual mode Open/Close pushbuttons<br>• Interlocked indication<br>• Fault indication<br>• Alarm Reset pushbutton |
| | Details | • Feedback delay setting indication |
| | Alarms | • Fail<br>• Fault |
| Instruments | Home | • Process Variable(s)<br>• Alarm / Fault indication<br>• Alarm Reset pushbutton |
| | Details | • Hi-Hi Alarm setpoint indication<br>• Hi-Hi Alarm delay setting indication<br>• Hi Alarm setpoint indication<br>• Hi Alarm delay setting indication |

| Equipment | Tabbed Page | Typical Content |
|---|---|---|
| | | • Low Alarm setpoint indication<br>• Low Alarm delay setting indication<br>• Low-Low Alarm setpoint indication<br>• Low-Low Alarm delay setting indication |

| Equipment | Tabbed Page | Typical Content |
|---|---|---|
| Electrical Power Meters | Home | • Voltage<br>  ○ Line-to-line (Vab, Vbc, Vca)<br>• Current:<br>  ○ Per Phase (Ia, Ib, Ic)<br>  ○ Demand (average of phases, Ia, Ib, Ic, and date/timestamp of peak demand)<br>• Power<br>  ○ Real Power<br>  ○ Reactive Power<br>  ○ Apparent Power<br>• Energy<br>  ○ kWh with timestamp since start of accumulated value<br>• Power Factor<br>  ○ Per phase<br>  ○ Total<br>• Frequency<br>• Harmonics<br>  ○ TDD<br>  ○ THD (Ia, Ib, Ic), (Vab, Vbc, Vca) |
| Power Circuit Breakers | Home | • State (open / closed) (from protection relay)<br>• Open / Close Command (if available)<br>• Average Line-to-Line Voltage (from protection relay)<br>• 3 Phase Currents (from protection relay)<br>• Power Factor (from protection relay)<br>• Average Reactive Power (from protection relay)<br>• Average Apparent Power (from protection relay)<br>• On the details page (tab):<br>  ○ Date of last trip / operation,<br>  ○ Cause of trip (first out),<br>  ○ Readings (Current, Voltage, Power) prior to trip. |

On the right side of the tab bar, provide links to resources that open in an external popup window or an external application. Links may be provided for, but not limited to, the following:

- Device Webpage: link to open the device webpage in a web browser window.
- Drawings: link to a set of drawings (typically in PDF format) for the equipment.
- Documents: link to an external document associated with the equipment.
- Help: link to help system.

Regarding the device webpage link, some field devices such as the Schneider Electric TeSys T intelligent overload have a built-in device webpage that is accessible through a web browser. The device webpage may be used by operators and maintenance personnel to view detailed information that is not provided on the HMI system.

The Help system link must be provided on equipment faceplates to open a help system for the specific equipment. Help systems are typically implemented with PDF documents and as such the Help link is right-aligned on the toolbar. If the help system is implemented within the HMI system (e.g. the information appears within the equipment faceplate, or a different popup) then the Help link in the toolbar should be left-aligned on the toolbar.

Numeric values and strings shall be shown on equipment faceplates using either the *Indicator* or *Input Field* graphic display objects. If the field shows a read-only variable, such as equipment running status, then an *Indicator* shall be used. If the field is read/write, such as the manual speed entry field for a VFD, then an *Input Field* shall be used.

A sample equipment faceplate for a VFD-driven pump is provided in Figure 2-8.

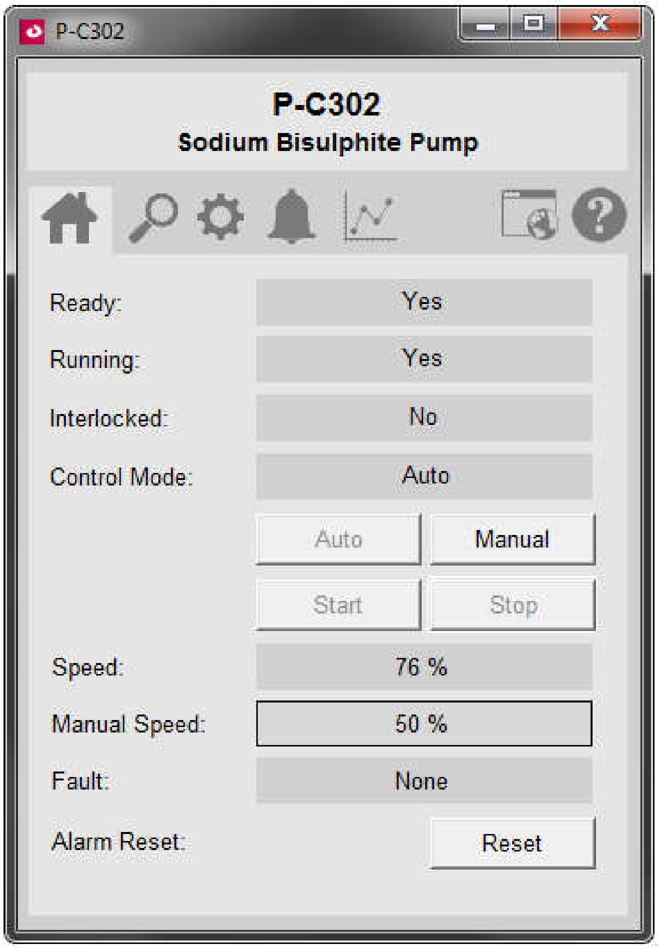



**Figure 2-8: Sample VFD Pump Equipment Faceplate**

*Notes:*

1. *The sample shown is for a VFD driven pump. The specific layout and information provided on equipment faceplates is dependent on the equipment type.*
2. *The equipment faceplate comprises multiple tab pages of information to group together common information and controls. As described in Table 2-4.*
3. *The device webpage and help system icons in the toolbar are on the right-side, implying these will open in a new window.*

4. *Up/Down arrows to increase/decrease the setpoint are not shown but should be included (similar to Figure 2.10). Increments are to be defined in PCN/FRS or defaulted to smallest increment defined (decimal place defined by device, set point, etc.)*

A sample PID controller faceplate is provided in Figure 2-9, and shall be used as the basis for PID controller faceplates.

The PID controller faceplate is organized in a specific manner, as follows:

1. The units of measure of the process variable are indicated in the top left corner.
2. The process variable (PV) is indicated in the centre with a vertical bar graph.
3. The shaded grey areas left of the PV bar graph represent alarm limits of the process variable.
4. The numeric display to the left of the PV bar graph represents the current process value.
5. The arrow and numeric indicator to the right of the PV bar graph represent the setpoint (SP).
6. The control variable (CV) output is indicated using a horizontal bar graph.

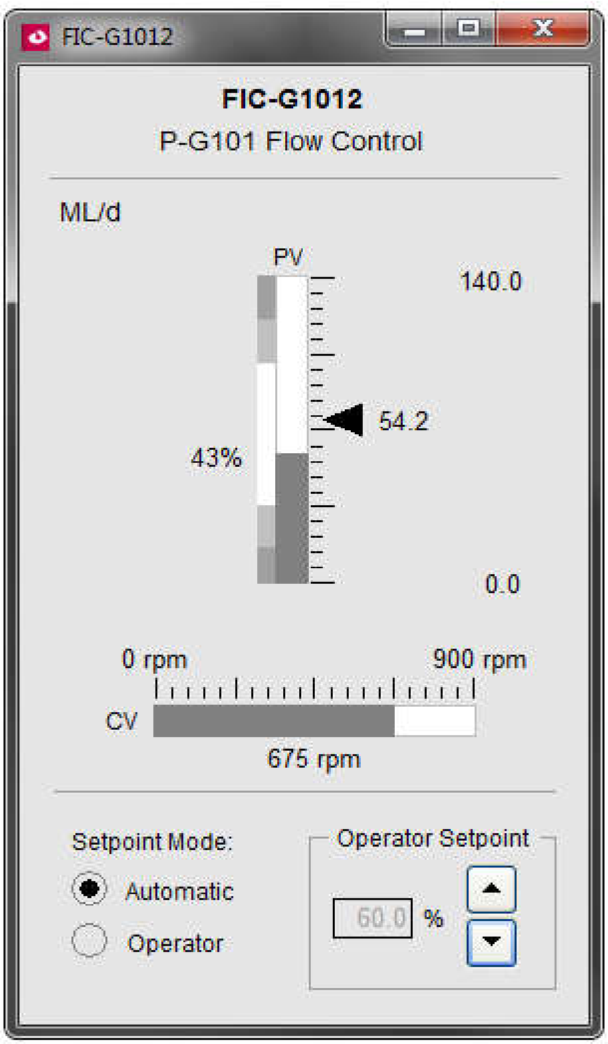



**Figure 2-9: Sample PID Controller Equipment Faceplate**

### 2.7.8 Trend Displays

Trend displays are provided for operators to view real-time and historical signals associated with an instrument or equipment. Trend displays may also be used to view setpoints, control limits, and alarm limits. Trends shall be adjustable by the user and those settings to remain until the trend is closed. Trend display will be opened through a link on displays where associated signal pens are related to.
Provide a sample trend to the City for review.

Trend displays are full screen displays and typically contain a single trend viewer object. For facility HMI systems that use Schneider Electric AVEVA Plant SCADA, the trend viewer object shall be the Process Analyst object. The amount of available data on the HMI server shall be enough to satisfy the plant requirements. For signals long term archived to the historian, the trend should be capable of showing current value and the long term archived value from historian.
Set the background colour of the trend object to *Black*. Thickness of the signal lines and thickness and color of the grid lines should be reviewed with the City and consistent with best practices. Default trend parameters will be submitted to City for review and approval.

The trend object shall show the engineering units of measure on the vertical axis, and time on the horizontal axis. Fixed scaling of the vertical axis is to be used and configurable, and operators may select automatic scaling values. Fixed scaling will be the default upon opening of any trend. The horizontal time axis should be scaled appropriately for the given signals. For example, if the trend is used to view daily flows, the range of the time axis should be set to 24 hours. These scales shall be reviewed by the City before implementation.

Zoom-in and Zoom-out option shall be provided to quickly change the time span. There should be option for Operators to add more signal pens to predefined trend, but not to save to the predefined trend. There should be option to add scooter/cursors onto the trend displaying the signal values at the scooter/cursor. The current signal values should be displayed on the signal span.

The engineering units of the signal should be displayed on the signal span.

### 2.7.9 Active Alarm Displays

Active Alarm displays are full-screen displays that show a listing of all active alarms for the facility or a process area. Active alarm display tab shall be opened by clicking alarm table on the header. The active alarm display shall display all alarms in the facility or all alarms for a specific process area depending on which area is clicked on the header page. Active alarm display shall be opened in a new tab if it is the first active alarm tab or it shall replace an existing active alarm tab. In case maximum number of tabs is reached, the tab on the most left is closed before the new tab is opened. Alarm display shall provide quick page up and page down button in addition to the scroll bar to facility the alarm browsing.

The active alarm display shall provide the following quick filter operation:

- Filter different alarm priorities
- Different process area
- Shelved alarms
- Suppressed alarms
- Out of service alarms
- Acknowledged alarms
- Unacknowledged alarms

The active alarm display shall provide a freeze button to temporarily stop the active alarm display being updated.

The active alarm display shall provide a comprehensive alarm filter where operator can choose time frame, including/excluding specific tags with capability to use wild characters, specific priorities, specific area, specific alarm tag type, and specific alarm status (i.e. high, high-high, return to normal, inactive, shelved, suppressed, out of service, bad quality, hardware failure, deviation alarm, acknowledges, unacknowledged, information and etc.).

The alarm display shall occupy the whole width of the screen with the minimum following columns:

- Alarm icons
- Group/Process Area
- Date and Time
- Equipment Tag name
- Equipment Tag description
- State of alarm.
- Acknowledged/Unacknowledged status

The column width should be automatically adjustable according to the content each column. The sequence of the column can be adjustable by drag and drop.

For facility HMI systems, clicking the three-line alarm summary in the header display takes the operator to an unfiltered active alarm display, showing all alarms at the facility. Clicking on a process area in the header's table of alarms takes the operator to a filtered active alarm display showing only the alarms for the selected process area.

Alarms shall be sorted by alarm occurrence with the most recent alarms appearing at the top.

Each alarm shall be colour coded as per the assigned priority; red for Priority 1, orange for Priority 2, and yellow for Priority 3 alarms. Unacknowledged alarms are shown using blinking text, and acknowledged alarms are shown using solid (non-blinking) text.

For each alarm, indicate the date and time of alarm occurrence, and the date and time of alarm acknowledgement.

Provide the ability to right-click on an alarm to view additional information on the alarm:

- Disable the alarm
- Acknowledge the alarm
- Operating parameters
- Operator Notes
- Operator Actions
- On-the-fly Trend
- Navigation to the alarming equipment associated display

Provide pushbuttons on the display to acknowledge alarms as follows:

- ACK – Acknowledge the selected alarm.
- ACK AREA – Acknowledge all unacknowledged alarms for the current process area (applicable only to filtered alarm summary displays for a specific process area).
- ACK PAGE – Acknowledge all unacknowledged alarms on the current alarm page.

- ACK ALL – Acknowledge all unacknowledged alarms.

Provide a means for operators to filter alarms by one or more user-defined text filters, including an ability for operators to filter or display disabled alarms. Some base filters would be priority, time, date and area.

The active alarm display should open and produce filtered result when filtering alarms in a reasonable time and subject to City review/approval.

### 2.7.10 Historical Events

The historical event display must include the historical alarms, operator actions, user login/logout information and PCS systems alarms. A historical event display should have a default time frame on opening with predefined filter for each process area. It shall provide quick buttons to change the time frame to back or forward by 2 hours, display events for the last 1 hour, 1 day, 1 week or 1 day and provide comprehensive custom filter function by selecting specific time frame, process area, specific tags, specific message, etc. It should include a query table that the Users can use to customize the data they want to appear on the alarm table list when required.

The historical events display should open and produce filtered result when filtering events in a reasonable time and subject to City review/approval.

## 2.8 Organization

Organize graphic displays in a hierarchical manner that allows operators to drill down for further information on a process area and/or equipment of interest. The display hierarchy shall mimic the facility equipment hierarchy. Hierarchy shall be reviewed by the City along with a detailed flow chart in the design phase.

Four display levels are defined within the display hierarchy, as follows:

- Level 1 displays are for facility dashboard displays such as the Facility Process Dashboard, Facility Process Flow Diagram, the Facility Security Dashboard, and help system.
- Level 2 displays are for process area dashboard displays.
- Level 3 displays are for process mimic displays.
- Level 4 displays are for equipment detail displays.

While distinct levels are defined within the display hierarchy, it is not required to follow a strict drill-down approach to display navigation. Shortcuts may be provided to jump from any level to any other level if it is practical for the operator. Left arrow, Right arrow and Up arrow shall be provided on the manual bar to navigate to previous and next page at same level and navigate to the upper level.
In most cases there will be a one-to-one relationship between the Level 3 and Level 4 displays but there may be cases where a one-to-one relationship does not exist.

A typical facility HMI application would have a display hierarchy like that shown in Figure 2-10.

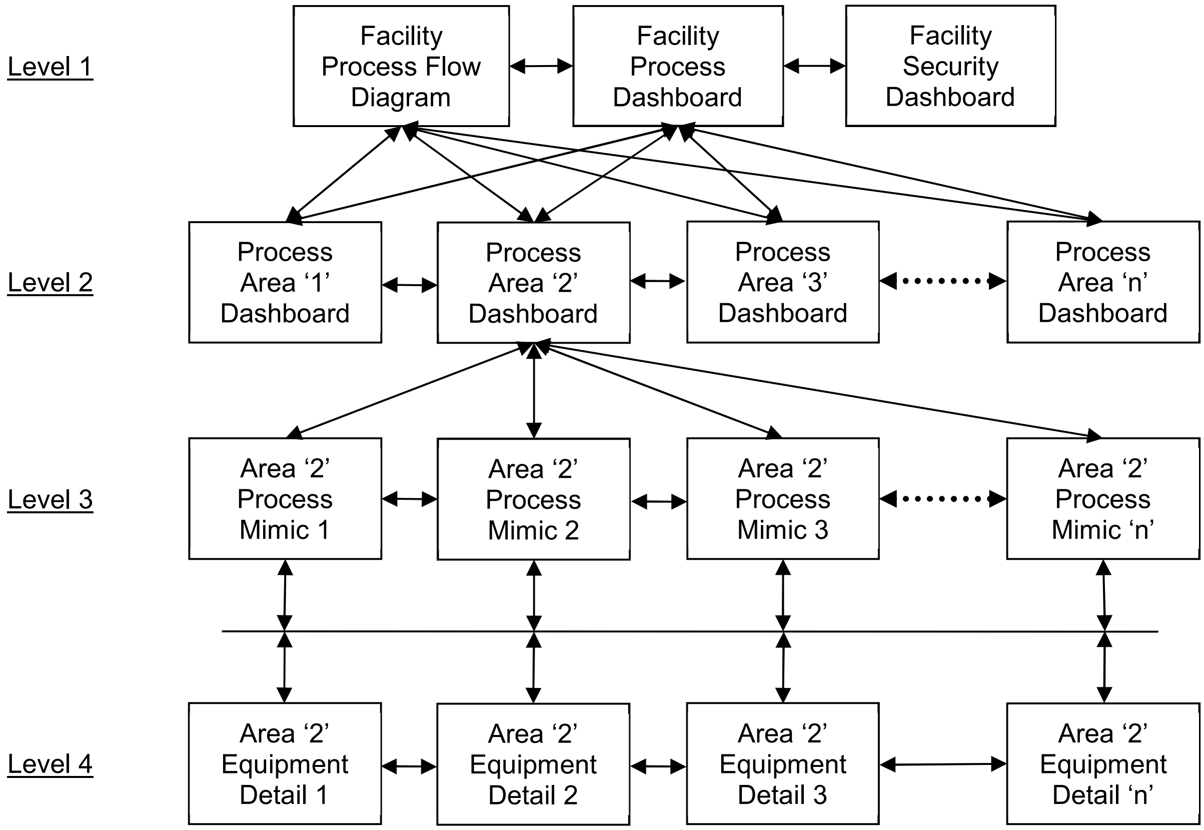



**Figure 2-10: Typical Facility HMI Application Display Hierarchy**

*Notes regarding* Figure 2-10*:*

1. *The Level 3 and Level 4 displays shown are associated with Process Area '2' only. A similar arrangement would exist for the other process areas.*
2. *Links between the Level 3 displays (process mimics) are typically provided using process and signal line continuation symbols.*
3. *A mesh is shown to represent the relationship between process mimics at Level 3 and the equipment detail displays at Level 4. The specific relationship is dependent on the equipment and the implementation of the displays.*
4. *Shortcuts between displays are omitted for clarity. For example, it may be possible to link from a Level 2 process area Dashboard to a Level 4 process detail display if such a shortcut was provided.*

# 3 ALARMING SYSTEM

## 3.1 Alarm Presentation Philosophy

For facility HMI systems, new alarms are presented in the three-line alarm banner within the header display. Unacknowledged alarms are to appear blinking in order to get the attention of the operator, and acknowledged alarms are shown using non-blinking text.

For touchscreen HMIs used for local equipment control based on the Schneider Electric Magelis HMI, new alarms shall appear in a scrolling marquee across the top of the screen, which is the default method for display alarms on the Magelis HMI terminal.

An alarm summary screen shall also be provided which lists the active and historical alarms.

Alarms associated with equipment shall be shown on the dashboard displays, process mimics, and equipment detail displays as per Section 2.6 for both facility HMIs and touchscreen HMIs for local equipment control.

## 3.2 Alarm Priorities

Three priority levels of alarms are defined within the HMI alarming system:

- Priority 1 – High Priority / Emergency. The alarm indicates a condition that required manual or automatic functions to avoid unacceptable operating conditions or product. Also, indicates a callout when unmanned. See Section 3.3 for further information on Alarm Callouts.
- Priority 2 – Medium Priority. The alarm indicates a condition that requires manual or automatic functions to avoid unacceptable operating conditions or product. The alarm requires attention, but on its own, does not require a callout when unmanned.
- Priority 3 – Low Priority. The alarm indicates a condition that may result in off-quality product or may lead to more severe consequences. Such as equipment override and alarm disabled.
- Priority 4 – Abnormal Condition. This priority indicates an abnormal condition that does not require immediate attention. In general, Local, Manual, or Not Remote mode alarms will be in this category.

NEWPCC currently uses two priority alarms. The number of alarm priorities should be confirmed prior to design.

Alarm priority levels for new alarms are to be specified in the project’s Enhanced Process Control Narratives (EPCNs).

## 3.3 Alarm Callouts

SEWPCC and WEWPCC are not manned 24 hours per day. After-hours Priority 1 alarms from these sites are monitored by NEWPCC Operations. Currently, a monitoring system (referred to as “Plantmonitor”) has been implemented by City staff to meet this requirement. Any changes to the alarming system at any of the three plants shall include the design and implementation of a system to ensure high after-hours Priority 1 alarms from SEWPCC and WEWPCC are effectively monitored at NEWPCC.

- NEWPCC shall monitor SEWPCC and WEWPCC “Operator” on duty status.
  - When a Priority 1 alarm occurs at SEWPCC or WEWPCC, a signal indicating occurrence of priority 1 alarm at SEWPCC or WEWPCC shall be sent to NEWPCC PCS; NEWPCC PCS shall confirm the signal received with positive feedback. If the respective facility operator is not on duty, the alarm will be activated at NEWPCC and the PA siren shall be activated.

- Heartbeat signals shall be implemented to monitor the communication between NEWPCC and SEWPCC, and between NEWPCC and WEWPCC. Alarms and siren shall be activated in case communication link breaks down.
- A separate Plantmonitor user interface shall provide detailed priority 1 alarm information to NEWPCC operators, including at least time stamp, tag name and tag description, and alarm status. The Plantmonitor user interface shall be available from any of the PCS operator workstations across the NEWPCC campus.

As the system is interacting among three facilities, any design change at SEWPCC or WEWPCC shall be coordinated with NEWPCC, and any design change at NEWPCC shall be coordinated with both SEWPCC and WEWPCC. Both the design consultant and the contractor are expected to work closely with the City to implement any change to the Plantmonitor system.

# 4 MISCELLANEOUS

## 4.1 Help System

A help system shall be provided for each HMI system that include the following:

1. A symbol legend for equipment, alarm icons, and abnormal state icons,
2. Display navigation procedures,
3. User login/logout procedures,
4. User security information, and
5. Operating procedures and equipment manuals for complex equipment as required.

## 4.2 Commands Originating from the HMI

Commands that originate from the HMI shall utilize the SET action, rather than the Momentary ON action. The PLC shall reset the bit after it is utilized in the program. This prevents discrete PLC tags from being stuck on in the event of communication failures, timing issues, or control from multiple HMI nodes.

## 4.3 HMI Security

HMI systems shall incorporate security to prevent unauthorized setpoint changes and to prevent unauthorized control of equipment. All graphic display objects that can change a tag value in a PLC shall incorporate user security. Typical examples of such display objects include pushbuttons for starting/stopping equipment and numeric input fields for setpoint adjustment.

Where a graphic display object is secured and the current user does not have the required access privileges, show the *Lock* icon inside the field to represent the fact that the field is currently locked.

Four levels of security are to be implemented as per Table 4-1 below.

| Security Level | User Job Function | Typical Capabilities | Typical Restrictions |
| --- | --- | --- | --- |
| Administrator | Automation and Industrial Controls Group | • System Administration/Configuration<br>• Viewing HMI<br>• Automatic mode control limit and control setpoint adjustment<br>• Manual equipment control<br>• Alarm acknowledgement<br>• Alarm limit adjustment<br>• Enabling and disabling alarms | • None |

| | | | |
|---|---|---|---|
| | | • Viewing reports, trends, and alarms | |
| Special (S) | Electrical and Instrumentation Group | • Operate medium voltage and distribution-related electrical equipment (4160V and above) if configured for operation from SCADA<br>• Operate 600V electrical equipment that is not limited to a single piece of equipment (e.g. one side of an MCC).<br>• Viewing HMI<br>• Viewing reports, trends, and alarms | • System Administration/Configuration<br>• Automatic mode control limit and control setpoint adjustment<br>• Manual equipment control<br>• Alarm acknowledgement<br>• Alarm limit adjustment<br>• Enabling and disabling alarms |
| High (H) | Senior Operator | • Operate single point 600V electrical equipment (e.g. a blower or HVAC unit).<br>• Viewing HMI<br>• Automatic mode control limit and control setpoint adjustment (This should be reviewed on a case by case basis with the City)<br>• Manual equipment control<br>• Alarm acknowledgement<br>• Alarm limit adjustment<br>• Enabling and disabling alarms<br>• Viewing reports, trends, and alarms | • System Administration/Configuration<br>• Operate medium voltage and distribution-related electrical equipment (4160V and above) if configured for operation from SCADA<br>• Operate 600V electrical equipment that is not limited to a single piece of equipment (e.g. one side of an MCC). |
| Low (L) | Operator | • Viewing HMI<br>• Manual equipment control<br>• Alarm acknowledgement<br>• Viewing reports, trends, and alarms | • Automatic mode control limit and control setpoint adjustment<br>• Alarm limit adjustment<br>• Enabling and disabling alarms |

**Table 4-1: HMI User Security Levels**

*Notes:*

1. *The capabilities and restrictions indicated above are typical. The functional requirements specification for each project may have different user security requirements.*
2. *The Administrator level users should have all the rights of a Senior Operator plus the system administration/configuration rights.*

Winnipeg

# The City of Winnipeg

## Water & Waste Department

# Sewage Treatment Plant
# Tag Naming Standard

Document Code: 612620-0014-40ER-0001

Revision: 00

| | | |
|---|---|---|
| Approved By: | Duane Griffin, Branch Head – WW Planning & Project Delivery | Sept 25, 2015<br>Date |

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# TABLE OF CONTENTS

# LIST OF TABLES

# 1 INTRODUCTION

This Water and Waste Department Sewage Treatment Plant Tag Naming Standard is to be referenced for consistent naming of software tags within the PLC (I/O, variables, and control system functions) and HMI. This standard is an extension of the Identification Standard, document 510276-0000-40ER-0002, and it follows the same rules. Where there are discrepancies between these two standards, this standard shall take precedence for PLC and HMI programming.

## 1.1 Scope of the Standard

This identification standard, document 510276-0000-40ER-0002, applies to all PLC, HMI, and SCADA systems in City-owned sewage treatment plants, which includes the following facilities:

1. North End Sewage Treatment Plant (NEWPCC)
2. South End Sewage Treatment Plant (SEWPCC)
3. West End Sewage Treatment Plant (WEWPCC)

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

## 1.2 Application

This Standard is meant as a guideline for control system developers to provide consistent tag naming across all City sewage treatment plants. Although every conceivable tag naming scenario cannot be covered in this document, developers are expected to follow the general intent and guidelines provided herein.

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 with consideration of the future arrangement of the facility, however general guidelines for application are presented as follows:

1. All new custom process control system applications developed for the City shall follow this standard. It is not expected that pre-developed PLC or HMI applications from packaged equipment vendors follow these rules, but where pre-developed PLC or HMI applications from a vendor allows customizable options by the vendor before delivery, the intent of this standard should be followed as reasonably practicable.
2. All new facilities must comply with this standard.
3. All upgrades to a facility that require the installation of a PLC or HMI must comply with this standard.
4. All minor upgrades to an existing control system should utilize this standard as far as practicable, however in some cases compromise with the existing control system identification practice may be required. For example, addition of new tags to the Bailey Infi90 control system.

## 1.3 Definitions

| | |
|---|---|
| Class | A template definition of the PLC and HMI logic, variables, and graphic symbols associated with a particular type of equipment. Within the Schneider Electric software, this is typically implemented as a Derived Function Block in the Unity Pro PLC programming software and a Genie or Super-Genie in the Vijeo Citect HMI software. |

| | |
|---|---|
| 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. These can be implemented either as an instance of a Derived Function Block or a grouping of Elementary Function Blocks. |
| Derived Function Block | A user-defined PLC function block containing custom logic and that has been added to the function block library. These are defined once and are instantiated for use in the PLC program. |
| Elementary Function Block | Predefined PLC function blocks in the function block library that typically cannot be modified by users. |
| *Equipment.Item* | Within the Vijeo Citect HMI software, this is a field for a Variable Tag. It is generated within the software by combining the *Equipment* and *Item Name* fields that are defined by the developer. When this term is used within this document it will be italicized. |
| FDT/DTM | Field Device Tool / Device Type Manger. A tool for configuring the communication interface between field devices and the PLC system. The Schneider Electric Unity Pro PLC programming software incorporates an FDT frame for loading device DTMs from the device manufacturers. |
| Instance | A specific realization of a class. Within the Schneider Unity Pro software, each time a Derived Function Block is used within a PLC program it is an instance of a class. |
| Parameter | An attribute (input, output, or internal variable) of a class or function block. This portion of the tag provides a name of the signal. |
| Tag | A variable utilized within a PLC or HMI program. 'Tag' is synonymous with 'Variable'. |
| *Tag Name* | The actual identifier assigned to a specific tag. When this term is used within this document it will be italicized. |
| Variable | Data used by a PLC or HMI that is stored at a unique memory address. 'Variable' is synonymous with 'Tag'. |
| *Variable Tag* | A term used in the Vijeo Citect HMI software that refers to an HMI tag that is linked to a PLC tag. It can be referenced within the HMI program by either the associated Tag Name or *Equipment.Item*. When this term is used within this document it will be italicized. |

## 1.4 Notes on Naming Conventions

In the following sections, the naming convention for tags and classes are defined in tables. The following notes offer an explanation of the conventions utilized within the tables:

1. A number of letters in succession represents a parameter that must have the same number of characters as the number of letters. For example, **NNN** in Section 4.2.1.1 indicates three digits must be used for the equipment number.
2. A letter with a star indicates a variable number of characters. For example, **X*** in Section 4.2.1.1 could represent between two and four characters.

## 1.5 References

The following City of Winnipeg standards may be referenced where applicable:

1. Water and Waste Department Identification Standard, document 510276-0000-40ER-0002,
2. Wastewater Treatment Electrical Design Guide, document 510276-0000-40ER-0002,
3. Wastewater Treatment Automation Design Guide, document 612620-0013-40ER-0001,
4. HMI Layout and Animation Plan, document 612620-0015-40ER-0001,
5. Historical Data Retention Standard, document 612620-0016-40ER-0001.

The following industry standards and guidelines may be referenced where applicable:

1. ANSI/ISA-5.1-2009, Instrument Symbols and Identification.

The following Schneider Electric help system documents may be referenced where applicable:

1. Unity Pro Help » Unity Pro Software » Languages Reference » Data Description » Syntax Rules for Type\Instance Names
2. Unity Pro Help » Unity Pro Software » Data Description » Data References » Data Naming Rules
3. Vijeo Citect Online Help – Tagging Process Variables, http://www.citect.schneider-electric.com/webhelp/vijeo2015/Content/Tagging_Process_Variables.html
4. Vijeo Citect Online Help – Tag Name Syntax, http://www.citect.schneider-electric.com/webhelp/vijeo2015/Content/Tag_name_syntax.html

# 2 BASIC RULES

## 2.1 General

In general, all tags utilized within the Process Control System (PCS) should be named in a manner that is consistent with how they are shown on the P&IDs. PCS tag names will include the identifier of the equipment or control system function they are associated with (e.g. P-P217.Run).

The City of Winnipeg Identification Standard, document 510276-0000-40ER-0002, uses hyphens and periods as separation characters within identifiers (e.g. VFD-G101.Flt). For PLC variables, Schneider Electric's Unity Pro software does not allow the use of hyphens in variable names and therefore hyphens must be replaced with underscores in PLC programs. Unity Pro only supports the use of periods in variable structures but not in regular variables. As such, it is required to replace periods with underscores for regular variables within PLC programs. For HMI variables, Schneider Electric's Vijeo Citect software does not support hyphens or periods, but does support backslashes ("\"). Therefore all hyphens will be replaced with underscores, and periods will be replaced with backslashes. Note that Vijeo Citect does support periods in the *Equipment.Item* hierarchy, which is further discussed in Section 5.

Variables shall be based on positive logic, with the "1 State" or 100% being the active state or full range of the signal. Tag naming should reflect this philosophy. I/O signals may use negative or fail safe logic, but they will need to be conditioned (negated in the discrete case) before use.

## 2.2 Format

Classes, function blocks, parameters, and variables implemented in the PCS shall be named using the following characters:

- Uppercase letters A through Z
- Lowercase letters a through z
- Numerals 0 through 9
- Underscore "_"
- Period "." (for PLC variables only)
- Backslash "\" (for HMI variables only)

All names shall start with a letter. Hyphens or spaces are not allowed in a name.

Periods are used in the PLC system as a separation character between a function block instance name and its parameters (eg. YC_P2041.CmdStart) and for tag structures. Periods are not used otherwise.

Periods are not permitted in HMI variable names and therefore backslashes are used in the HMI system as a separation character between a function block instance name and its parameters (eg. YC_P2041\CmdStart).

Where possible, use ISA 5.1 style identification as per Table 4.1 in ANSI/ISA-5.1-2009 for naming classes, function blocks, parameters, and variables (eg. "F" for flow, "P" for pressure, "C" for control, etc.). Where ISA 5.1 variables are used, they shall be capitalized. If ISA 5.1 variables are not suitable, English words, abbreviations, or acronyms may be used.

Where English words or abbreviations are used within a name, each will begin with an upper case letter and the remaining letters in lowercase. Additionally, acronyms are completely capitalized.

Names shall be unique. Names differing only in the use of lowercase and uppercase letters are not permitted (e.g. FAL and Fal).

## 2.3 Standard Abbreviations and Acronyms

Abbreviations and acronyms may be used in the naming of objects where ISA 5.1 style identification is not suitable. Note that it is permitted to use ISA 5.1 style identification along with abbreviations and acronyms in the naming of an object. The purpose of using abbreviations and acronyms, rather than complete English words, is to minimize the length of object names.

Standardized abbreviations and acronyms used in the identification of classes, function blocks, parameters and variables are provided in Appendix B.

It may be required to add new standard abbreviations or acronyms, where the existing list does not cover a new application. In this instance, the proposed abbreviation or acronym is to be reviewed with the City, and if approved then it shall be added to the list in Appendix B.

If additional abbreviations are used, ensure that they are consistently applied throughout the entire PLC and HMI program.

## 2.4 Concatenation

When concatenating multiple words or abbreviations to form a name or a part of a name, no spaces or underscores shall be present between identifiers or abbreviations, with the following exceptions:

- If a name or part of a name is formed by concatenating two strings and the first string ends with a number, an underscore ("_") will be used to separate the two strings:
    - E.g. "Eqmt1_Rdy" contains an underscore following "Eqmt1" because it ends with a number.
- All letters in ISA 5.1 style identifiers and variables are capitalized, therefore they will be separated from succeeding identifiers or abbreviations with an underscore ("_")
    - E.g. "KQ_Rst" contains an underscore following the "KQ" variable because it ends with a capital letter.
    - E.g. "F_Max" contains an underscore following the "F" variable because it ends with a capital letter.
- All letters in acronyms are capitalized, therefore they will be separated from succeeding identifiers or abbreviations with an underscore ("_")
    - E.g. "HOA_Auto" contains an underscore following the "HOA" acronym because it ends with a capital letter.

# 3 CLASSES

A class is a template that is used to create an object within the PCS. A typical class is a collection of PLC program logic together with HMI graphic objects. The PLC portion of a class is implemented in the Schneider Electric Unity Pro software using a Derived Function Block. The HMI portion of a class is implemented in Vijeo Citect using a Genie or Super-Genie that is linked to *Equipment* object(s) in Vijeo Citect.

A number of standard classes are currently in development for the City's Sewage Treatment Program. Contact the City for the current status on the development of these classes, and to obtain copies of completed classes. Additional classes may be developed as required for common control system functions to allow for rapid system development.

New classes that are developed shall be named in a manner that gives a clear indication of the functionality contained in the class. All class names shall follow the basic rules indicated in Section 2. Where the class could be used for different types of equipment, it should be named generically enough so that the name fits all pieces of equipment (e.g. EqmtStatus as opposed to MotorStatus).

Not all PLC program logic is necessarily templated from a class. In some cases, program logic may be implemented using Elementary Function Blocks in the PLC program. However, all variables read by the HMI system should be read from a derived function block (class) within the PLC.

# 4 PLC TAGS

## 4.1 I/O Tag Format

The tag naming standard for I/O signals is as per the City of Winnipeg Identification Standard, document 510276-0000-40ER-0002, Section 7.8.

The tag naming standard for fire alarm signals is as per the City of Winnipeg Identification Standard, document 510276-0000-40ER-0002, Section 6.7.

### 4.1.1 I/O Signal Conditioning

Input signals from physical I/O or a communication network require conditioning before being used in the PLC program. This is to ensure that all input signals remain constant throughout the program scan, and also allows for input channel re-assignment, signal inversion, and scaling if necessary. Input signal conditioning is performed in separate input signal conditioning routines. Likewise, output signals shall be mapped to the respective physical or network outputs in an output signal conditioning routine. While output signals do not always require conditioning, output channel reassignment may be required in the future, which would be performed in the output signal conditioning routine.

Signals directly associated with physical I/O or networked devices are called raw signals, and the tag name for all raw signals shall have an underscore appended to it.

The I/O conditioning logic may include a check on the quality of the signal. An error status will be set when there is a clear indication that the values are not being read or written properly, the wires are disconnected or shorted, or in the case of analog signals, the values are overrange or underrange (the possible checks depend on the I/O card and type of wiring). The tag indicating bad quality will be the conditioned I/O tag plus "_Err".

Examples:

| | |
| --- | --- |
| TSH_M6011_ | Temperature switch raw input. |
| TSH_M6011 | Temperature switch conditioned input. |
| TSH_M6011_Err | Temperature switch input bad quality status. |

Refer to the implementation examples in Section 4.5 for detailed I/O signal conditioning implementations for both physical I/O and networked devices.

## 4.2 Control System Functions

### 4.2.1 Control System Function Naming

#### 4.2.1.1 Control System Functions for Devices

Control system functions shown on P&IDs or described in the Functional Requirements Specification (FRS) shall be given an ISA 5.1 style tag. These functions typically are directly related to the control and monitoring of a particular piece of equipment or instrument, and the Loop Number will be determined from the equipment or instrument Loop Number. The identifier of the Control System Function implemented in the PLC and HMI should match the identifier of the Control System Function shown on the P&ID.

The identification format for control system functions for devices is as follows:

| X* | - | P | NNN | T |
|---|---|---|---|---|
| Functional Designation | - | Process Area | Equipment Number | Instrument Number |
| | | | Loop Number | |

Where,

X* is the *Functional Designation*, which is typically composed of two to four uppercase letters based upon ISA 5.1. Common Functional Designations are shown below:

**Table 1 – Common Functional Designations**

| Functional Designation | Description |
|---|---|
| YC | Controller for a major piece of equipment |
| XC | Controller for a valve or damper with discrete states |
| YL | Indicator for equipment with discrete states |
| PAL, LAL, etc. | Alarms |
| LIC, FIC, etc. | Controller of an analog variable |
| LI, FI, etc. | Indicator of an analog variable |
| FK | Control Station to allow HMI override |

P is the *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 as per Identification Standard, document 510276-0000-40ER-0002.

NNN is the *Equipment Number* of the associated equipment.

T is the *Instrument Number* of the associated instrument.

NNNT is the Loop Number of the associated equipment, composed of the *Equipment Number* together with the *Instrument Number*.

Examples:

YC-G1010 Controller for pump P-G101.

YL-B6510 Indicator for boiler BLR-B651. Note that there could be multiple signals being indicated.

FI-G2346 Flow indicator associated with flowmeter FIT-G2346.

LAH-R2100 Digital alarm/indicator to indicate high level alarm from high level switch LSH-R2100.

#### 4.2.1.2 Control System Functions for Overall Control Schemes

Control system functions for overall control schemes provide higher level control for multiple pieces of equipment and shall be given an identifier similar to control system functions for devices.

The first and second digits of the loop number should match the first and second digits of the associated equipment loop numbers. The fourth digit should be a “0”, however this may not always be possible as it may conflict with an existing loop number assigned to an instrument. If a loop number ending in “0” would result in a conflict, consider using a loop number that ends with “8” or “9” to reduce potential conflicts with other instrumentation. In more complex controllers, a new Loop Number should be chosen.

The PLC logic for an overall control scheme is not required to be encapsulated in a Derived Function Block, however, a separate subroutine (logic diagram) should generally be provided.

The identification format for overall control schemes is as follows:

| **X*** | **-** | **P** | **NNNN** | _ | **F*** |
|---|---|---|---|---|---|
| Functional Designation | - | Process Area | Loop Number | _ | Functional Description |

Where,

X* is the *Functional Designation*, which is typically composed of two to four uppercase letters based upon ISA 5.1. Common Functional Designations are provided in Table 1 above.

P is the *Process Area.* The process area code identifies the physical area or building in which the overall control scheme is used. A single letter character from A to Z represents a process area as per Identification Standard, document 510276-0000-40ER-0002.

NNNN is the *Loop Number*, which is a four digit number assigned to the control scheme. Where the overall control scheme is associated with equipment, the first and second digits of the Loop Number should match that of the equipment numbers.

F* is a description of the functionality. This should adequately describe the function to allow for easy interpretation of its purpose.

Examples:

XC-R4100_MasterController — Master controller for blowers B-R411, B-R412, B-R413, and B-R414.

YC-P2001_DestSelector — Controller that determines which location sludge should be pumped to.

### 4.2.2 Alarm Tags

Identification of alarms that are generated directly from a discrete input will be as per Section 4.2.1.1.

Identification of alarms that are not generated directly from a discrete input will be as follows:

| **C*** | **s** | **A*** |
|---|---|---|
| Control System Function | . | Alarm Designation |

Where,

C* is the *Control System Function* tag, as defined in Section 4.2.1.

s is the *Separation Character*. If the *Control System Function* is an instance of a class, this will be a dot. If not, it will be an underscore.

A* is the *Alarm Designation*, which uses ISA alarm designations where possible. Where ISA alarm designations are not used, the Alarm Designation shall be composed of the letters “Alm” followed by a description of the alarm using abbreviations and acronyms where possible.

Examples:

| | |
|---|---|
| XC-G6121.ZAO | An Open Fail Alarm associated with valve XC-G6121. |
| YC-B6710.PAL | Pressure Alarm for Low Seal Water from the YC-B6710 controller, which is associated with pump P-B671. |
| YC-S2160_AlmNoPumpsAvail | No Sludge Pumps available to run. YC-S2160 is a control system function for an overall control scheme, not an instance of a class. |

### 4.2.3 Alarm Limit Tags

Identification of analog limit values for the generation of alarms will be as follows:

| **C*** | **s** | **A*** | _ | **LMT** |
|---|---|---|---|---|
| Control System Function | . | Alarm Designation | _ | Limit Designation |

Where,

C* is the *Control System Function* tag, as defined in Section 4.2.1.

s is the *Separation Character*. If the *Control System Function* is an instance of a class, this will be a dot. If not, it will be an underscore.

A* is the *Alarm Designation*, which uses ISA alarm designations where possible. Where ISA alarm designations are not used, the Alarm Designation shall be composed of the letters “Alm” followed by a description of the alarm using abbreviations and acronyms where possible.

LMT is the *Limit Designation*, which is composed of the letters “LMT”.

Example:

TI-G6031.AlmHiHi_LMT A High-High Temperature Alarm Limit setting for TI_G6031.

### 4.2.4 Control Loop Variables

Identification of control loop variables for PID control loops, will be as follows:

| **C*** | **s** | **F*** |
|---|---|---|
| Control System Function | . | Control Loop Functional Designation |

Where,

C* is the *Control System Function* name, as defined in Section 4.2.1.

s is the *Separation Character*. If the *Control System Function* is an instance of a class, this will be a dot. If not, it will be an underscore.

F* is the Control Loop Functional *Designation* defined in the table below:

**Table 2 – Common Control Loop Functional Designations**

| **Functional Designation** | **Description** |
|---|---|
| PV | Process Variable |
| CV | Control Variable |
| Auto_SP | Setpoint when in Auto Mode |
| Oper_SP | Setpoint from Operator via HMI |

Note that the above list is not exhaustive, and for other types of control loops (i.e. other than PID control), other functional designations may be required. Use ISA 5.1 style identification, and/or the standard abbreviations and acronyms found in Appendix B, for naming these control loop functional designations.

Examples:

FIC-S1501.PV — The process variable (flow signal) for PID controller FIC-S1501 from flow meter FIT-S1501.

LIC-R4001.CV — The control variable (output signal) from the PID controller LIC-R4001 associated with tank TK-R400.

TIC-R6021.Auto_SP — The automatic mode setpoint for PID controller TIC-R6021.

## 4.3 Internal Variables

Identification of internal variables not associated with a specific piece of equipment or instrument loop, where the variable will be not used beyond the originating PLC, will be as follows:

| **C*** | **s** | **F*** |
|---|---|---|
| Control System Function | . | Signal Description |

Where,

C is the *Control System Function* name, formatted as per Section 2.2. Where the *Control System Function* name is associated with multiple pieces of equipment, a name is chosen that has some commonality with the identifiers of the equipment.

s is the *Separation Character*. If the *Control System Function* is an instance of a class, this will be a dot. If not, it will be an underscore.

F* is the *Signal Description* composed of abbreviations and acronyms where possible. This should adequately describe the signal to allow for easy interpretation.

Examples:

YC_S6001_State — The state variable for the state controller controlling Wet Well ventilation.

YC_G1000_WeatherMode — A discrete variable indicating Summer or Winter mode associated with the raw sewage pumps.

## 4.4 Global Variables

In some cases it will be required to read a variable from another PLC. A variable that is read from another PLC shall be considered a global variable. The global variable in the destination PLC shall be identified as follows:

| **GBL** | **P** | **NNN** | _ | **T*** |
|---|---|---|---|---|
| Global Designation | Process Area | PLC Equipment Number | _ | Originating Tag Name |

Where,

| | |
|---|---|
| GBL | is the *Global Designation*, consisting of the letters “GBL”. |
| P | is the *Process Area* of the originating PLC. |
| NNN | is the *Equipment Number* of the originating PLC. |
| T* | is the *Originating Tag Name,* which is the name of the tag that is being read from the remote PLC. |

Examples:

| | |
|---|---|
| GBL_R801_AIC_R1051.PV | The process variable associated with PID controller AIC-R1051 originating from PLC-R801. |
| GBL_P801_FI_P1081 | Flow signal from flow meter FIT-P1081 originating from PLC-P801. |

## 4.5 Implementation Examples

### 4.5.1 Hardwired Motor Starter

The P&ID example below shows scum recirculation pump P-P217 with control system function YC-P2170. As per the Identification Standard, document 510276-0000-40ER-0002, the inputs are P-P217.Run, P-P217.Rem, and P-P217.PSL, and the output is P-P217.CmdRun.

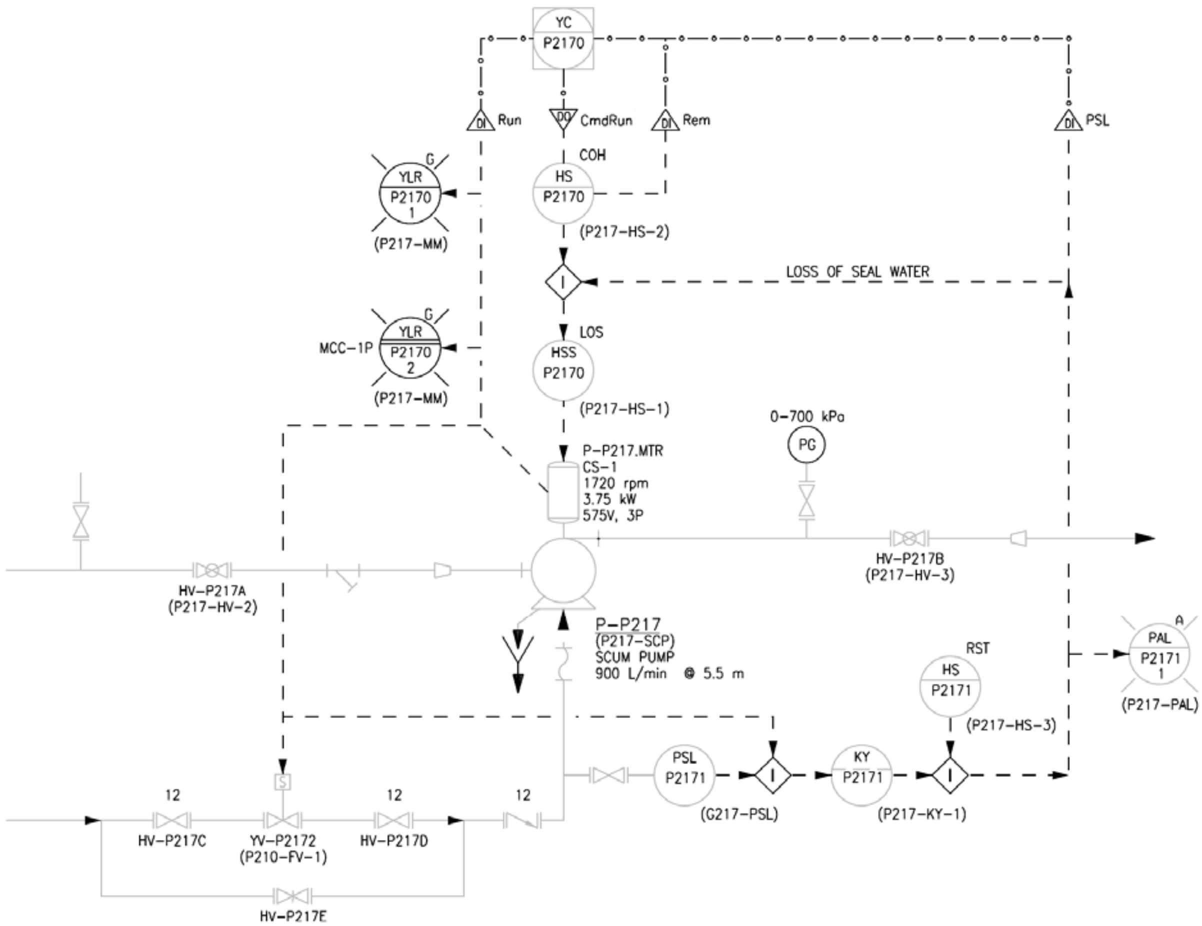


**Figure 4-1 – Example P&ID for Hardwired Motor Starter**

The raw PLC input tags before conditioning are:

- P_P217_Run_
- P_P217_Rem_
- PSL_P2171_

Within the input conditioning routing, the raw PLC input tags are conditioned to the following tags:

- P_P217_Run
- P_P217_Rem
- PSL_P2171

The function instance YC-P2170 will reside in the pump subroutine and will have the above conditioned PLC tags mapped to the following input parameters (not all parameters are shown):

- YC_P2170.Run
- YC_P2170.Rem
- YC_P2170.PSL

Some of the HMI commands that interface with the YC-P2170 function instance are:

- YC_P2170.ManStart
- YC_P2170.ManStop
- YC_P2170.Rst

YC-P2170 will have the following class output and alarm parameters (not all parameters are shown):

- YC_P2170.CmdRun
- YC_P2170.PAL
- YC_P2170.AlmRunFlt

Within the pump subroutine, the YC_P2170.CmdRun output will write to the following tag:

- P_P217_CmdRun

Within the signal conditioning routine, the P_P217_CmdRun tag will write to the following raw PLC output tag:

- P_P217_CmdRun_

### 4.5.2 Networked Motor Starter

The P&ID example below shows a fermenter recirculation pump P-D321 with control system function YC-D3210. The starter associated with this pump is a networked starter (eg. Schneider Electric TeSys T), and as such there will be a significant amount of data that can be read from the starter.

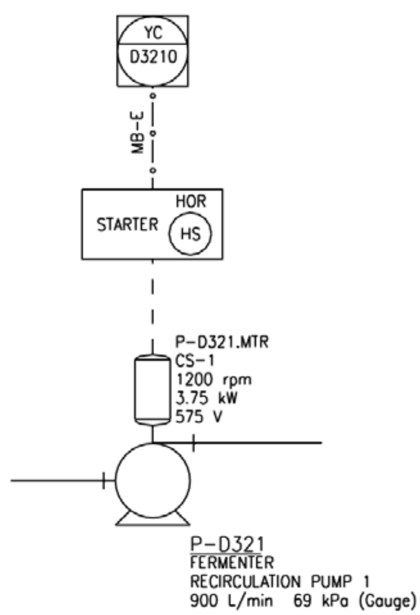


**Figure 4-2 – Example P&ID for Networked Motor Starter**

The control system function YC-D3210 is implemented as an instance of a PumpBasic class, which is a class developed for the City of Winnipeg Sewage Treatment Program. Within the PLC, the PumpBasic derived function block (DFB) does not perform the actual data exchange with the networked motor starter. The PumpBasic DFB is linked to a TeSys DFB that was developed by Schneider Electric, which performs the data exchange. The identifier for the TeSys DFB instance should be the same as the control system function but with an underscore ("_") appended to the identifier (eg. YC_D3210_).

The PumpBasic DFB would reside in the subroutine dedicated to overall control and functionality of the equipment. The TeSys DFB would reside in a signal conditioning routine since it maps the raw (unconditioned) networked I/O signals to conditioned PLC tags.

The input and output pins of the TeSys DFB connect to conditioned tags within the signal conditioning routine. Conditioned tags do not end with an underscore. These conditioned tags then connect to the input and output pins of the PumpBasic DFB in the equipment subroutine.

The following provides an example of linking some of the signals between the TeSys DFB and the PumpBasic DFB. Due to the quantity of signals associated with the TeSys DFB, not all signals are included in this example.

Within the signal conditioning subroutine, some of the signals obtained from the TeSys DFB are written to the following conditioned tags:

- P_D321_Rdy
- P_D321_Running
- P_D321_Flt
- P_D321_I_Avg

In the pump subroutine, the above conditioned tags are connected to the following pins on the YC-D3210 PumpBasic DFB:

- YC-D3210.StarterRdy
- YC-D3210.Run
- YC-D3210.Flt
- YC-D3210.I_Avg

YC-D3210 will have the following class output parameters (not all parameters are shown):

- YC-D3210.CmdRun

Within the pump subroutine, the YC-D3210.CmdRun output writes to the following tag:

- P_D321_CmdRun

Within the signal conditioning routine, the P_D321_CmdRun tag is connected to the 'Run_fwd' input pin on the TeSys DFB.

### 4.5.3 Instrument-Valve Control Loop

The P&ID example below shows a control loop consisting of a flow meter and modulating valve. Both of these devices utilize a PROFIBUS connection for communication with the process control system.

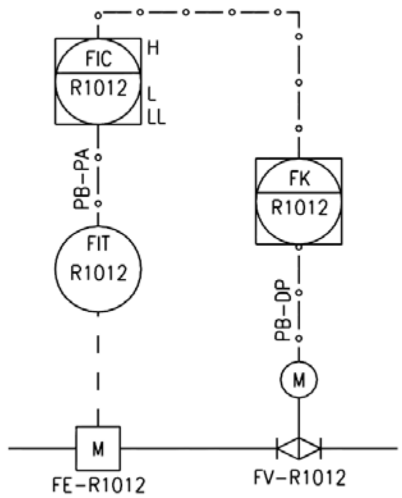


**Figure 4-3 – Example P&ID for Instrument-Valve Control Loop**

The control system function associated with the flowmeter (FIC-R1012) is an instance of the PID_Controller class, and the control system function associated with the valve (FK-R1012) is an instance of the LdStn (Loading Station) class. The FIC-R1012 PID controller accepts a process variable input, computes the control variable based on the setpoint, and outputs the control variable to the FK-R1012 loading station. The loading station accepts the valve position command and passes it on to the network output tag that controls the valve position. The loading station also monitors the position of the valve and generates alarms as required, and facilitates manual control of the valve via the HMI.

Within the PLC, the FIC-R1012 and FK-R1012 derived function blocks (DFBs) do not perform the actual data exchange with the networked devices. The data exchange is performed via a networking service within the PLC, which reads/writes data from/to the tag structures that were created by the FDT/DTM tool in Unity Pro.

The input and output tag structures created by the FDT/DTM tool should be named the same as the field device with "_IN" and "_OUT" appended to their name (eg. FIT_R1012_IN, FIT_R1012_OUT, FK_R1012_IN, and FK_R1012_OUT). Within these structures are status and control variables that are used by the PLC, and the names of these variables may or may not be pre-defined by the device manufacturer. Where the variable names are already pre-defined, they should not be renamed. However, if the variable names are not pre-defined, they should be renamed to be consistent with the standards outlined in this document.

In the following example, it is assumed that the variable names in the input and output structures have not been defined by the manufacturer, and that they have been renamed.

The flow signal in the input structure associated with the flow meter is:

- FIT_R1012_IN.F

Within the input signal conditioning routine, the above tag writes to:

- FIT_R1012_F

Within the equipment subroutine, the conditioned flow signal tag writes to the process variable (PV) input of the PID controller:

- FIC_R1012.PV

The output (control variable) of the PID controller is:

- FIC_R1012.CV

The control variable from the PID controller writes to the CV input of the valve's loading station:

- FK_R1012.CV_In

The output from the valve's loading station will be:

- FK_R1012.CV

The output from the valve's loading station writes to the position command variable in the output structure associated with the valve:

- FK_R1012_OUT.CmdZ_

The position feedback from the valve is stored in the following variable within the valve's input structure:

- FK_R1012_IN.Z_

The above position feedback variable is written to the feedback input of the loading station:

- FK_R1012.Fbk

# 5 HMI TAGS

## 5.1 General

The Vijeo Citect HMI software has a database to store HMI tags. Each record in the database is called a *Variable Tag*. Within each *Variable Tag* record there are two fields which can be used to identify the tag. These fields are called *Tag Name* and *Equipment.Item*. The *Equipment.Item* format allows for tags to be organized in a hierarchical fashion and provides additional options for searching for a specific tag.

Most of the data read by the HMI will be from derived function block parameters in the PLC since most of the logic will be templated from classes. However, in some cases the PLC logic will not be templated from a class and the HMI will read PLC tags. Where the HMI reads data from a derived function block parameter in the PLC, the *Tag Name* and *Equipment.Item* fields of the HMI variable tag are required to be populated so that the HMI tag links to HMI Equipment objects. In cases where the HMI reads PLC tags, typically only the *Tag Name* field is required.

It is not expected that the HMI will write to PLC tags directly. An instance of a derived function block should be used whenever practical. For example, when an output is not dependent on a measured process variable but can be varied only by manual adjustment, a manual loading station function block should be implemented instead of having the HMI write to the output directly.

## 5.2 *Tag Name* Format

### 5.2.1 HMI Tags associated with Derived Function Block Parameters

For HMI tags that are associated with derived function block parameters in the PLC, the *Tag Name* field will be identical to the function block instance name and the parameter name but with all periods replaced with a backslashes (“\”):

| **T*** | **** | **P*** |
|---|---|---|
| Function Block Instance Name | \ | Function Block Parameter Name |

Where,

T* is the associated PLC function block instance name.

P* is the associated PLC function block parameter name.

Examples:

| | |
|---|---|
| YC_R2050\Run | The running status signal from the YC-R2050 pump controller. |
| LIC_R4001\ManSP | The manual mode setpoint for PID controller LIC-R4001. |

### 5.2.2 HMI Tags associated with PLC Tags

For HMI tags that are associated with PLC variables (instances of elementary data types or derived data types), the *Tag Name* field will be identical to the associated PLC tag name with any periods replaced with backslashes (“\”):

| **T*** |
|---|
| Associated PLC Tag |

Where,

T* is the associated PLC tag with any periods replaced with backslashes.

Examples:

YC_R2050\Run The running status signal from the YC-R2050 pump controller.

LIC_R4001\ManSP The manual mode setpoint for PID controller LIC-R4001.

## 5.3 *Equipment.Item* Format

The format for the HMI *Equipment.Item* field will be as follows:

| **P** | **.** | **E*** |
|---|---|---|
| Process Area | . | Equipment / Instrument Identifier |

Where,

P is the *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.

E* is the Equipment or Instrument Identifier related to the signal.

The format for the *Item Name* field should be as follows:

| **F*** |
|---|
| Signal Description |

Where,

F* is the *Signal Description* using abbreviations and acronyms where possible.

## 5.4 Example

The following table shows some of the HMI tag names and *Equipment.Item* names for pump P-S217 and control function YC-S2170 shown in Section 4.5.

| PLC | HMI | |
|---|---|---|
| | **Tag Name** | **Equipment.Item** |
| YC_S2170.Run | YC_S2170\Run | S.P_S217.Run |
| YC_S2170.Flt | YC_S2170\Flt | S.P_S217.Flt |
| YC_S2170.PAL | YC_S2170\PAL | S.P_S217.PAL |
| YC_S2170.Rst | YC_S2170\Rst | S.P_S217.Rst |

Additional examples are shown in the table below.

| PLC | HMI | |
|---|---|---|
| | **Tag Name** | **Equipment.Item** |
| TI_B6471.PV | TI_B6471\PV | B.TI_B6471.PV |
| PAL_B5451.Out | PAL_B5451\Out | B.PAL_B5451.Out |

# Appendix A

# A.1 Field Equipment Identification

The following is provided as a summary of instrument and equipment identification found in the Identification Standard, document 510276-0000-40ER-0002.

## A.1.1 Instrument Identifier Format

As per Section 7.1.1 in the Identification Standard, document 510276-0000-40ER-0002, the identification format for instrumentation is as follows.

| **FFFF** | **-** | **XXXX** | **-** | **P** | **NNN** | **T** | **-** | **S** |
|---|---|---|---|---|---|---|---|---|
| Facility Code (Optional) | - | Instrument Functional Designation | - | Process Area | Equipment Number | Instrument Number | - | Suffix |
| | | | | | Loop Number | | | |

Where,

| | |
|---|---|
| FFFF | is the *Facility Code*. The *Facility Code* will typically be implied, and would only be fully written where required. |
| XXXX | is the *Instrument Functional Designation*, which is typically composed of two to four characters based upon ISA 5.1. Note that five character *Instrument Functional Designations* are possible, but should be quite rare. |
| P | is the *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. |
| 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, composed of the *Equipment Number* together with the *Instrument Number*. |
| 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. |
| 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. |

### A.1.2 Mechanical, Electrical and Automation Equipment Identifier Format

As per Sections 4.1, 6.1, and 7.2.1 in the Identification Standard, document 510276-0000-40ER-0002, the identification format for mechanical, electrical and automation equipment, other than instrumentation, 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*. The *Facility Code* will typically be implied, and would only be fully written where required.

EEEE — is the *Equipment Functional Designation*, which is composed of two to four characters.

P — is the *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.

NNN — is the *Equipment Number*.

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:

| | |
|---|---|
| CMP-G201 | A compressor in the G process area. |
| P-M645 | A glycol pump in the M process area. |
| R-R102 | A reactor in the R process area. |
| MCC-M701 | A MCC located in the M process area |
| DS-G510 | A disconnect switch for pump P-G510. |
| CB-M723-B | The second (alternate) breaker feeding PNL-M723. |
| 0101-PLC-G801 | A PLC located in the Grit process area of the NEWPCC facility. |
| ADP-G110 | An automation device panel dedicated to pump P-G110. |

### A.1.3 Subcomponent Identifier Format

As per Section 2.6 in the Identification Standard, document 510276-0000-40ER-0002, 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.

| **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.

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)

## A.1.4 Facility Code

As per Section 2.2 in the Identification Standard, document 510276-0000-40ER-0002, each City of Winnipeg facility is assigned a unique, four-digit facility code. 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. Thus, it is typically not included in PLC and HMI tags.

# Appendix B

## B.1 Standard Abbreviations and Acronyms

**Table 3 – Standard Abbreviations**

| Abbreviation | Description |
|---|---|
| Accum | Accumulated / Accumulator |
| Act | Action |
| Alm | Alarm |
| Alt | Altitude |
| Avail | Available |
| Auto | Automatic |
| Avg | Average |
| Chan | Channel |
| Cls | Close |
| Cmd | Command |
| Comm | Communication |
| Compl | Complete |
| Cont | Continuous |
| Ctrl | Control |
| Curr | Current (eg. Current Selection) |
| CV | Control Variable |
| Dest | Destination |
| Dia | Diameter |
| Dis | Disable |
| Dly | Delay |
| Elec | Electrical |
| Enb | Enable |
| Eqmt | Equipment |
| Err | Error |
| Gen | General |
| Fail | Failure |
| Fbk | Feedback |
| Flt | Fault |
| Fwd | Forward |
| Hi | High |
| In | Input |
| Intlk | Interlock (Input) |
| Intlked | Interlocked (Output) |
| Lmt | Limit |
| Lo | Low |

| Abbreviation | Description |
|---|---|
| Op | Operator |
| Opn | Open |
| Out | Output |
| PV | Process Variable |
| Man | Manual |
| Max | Maximum |
| Mid | Middle |
| Min | Minimum |
| Num | Number |
| Pos | Position |
| RC | Rate of Change |
| Rdy | Ready |
| Req | Request / Requested |
| Rem | Remote |
| Rev | Reverse |
| Rst | Reset |
| Tgt | Target |
| Sel | Select / Selection / Selected |
| SP | Setpoint |
| Vol | Volume |
| Warn | Warning |

### B.1.1 Additional References

Fluid commodity codes may also be used in the naming of classes, function blocks, parameters, and variables. Refer to Table 5-2 in the City of Winnipeg Identification Standard, document 510276-0000-40ER-0002 for the complete list of standard fluid commodity codes.

# The City of Winnipeg

## Water & Waste Department

# Electrical Design Guide

Document Code: 510276-0000-47ER-0001

Revision: 05

| | | |
| --- | --- | --- |
| Approved By: | Duane Griffin, Branch Head- WW Planning and Projects | Feb 14, 2020<br>Date |

| | |
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| Original Rev 00 Preparation by SNC Lavalin Inc. | |
| Prepared By: | C. Reimer<br>N. Bradoo<br>B. Cleven |
| Checked By: | C. Weiss-Bundy<br>E. Ryczkowski |

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# TABLE OF CONTENTS

# 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 design requirements to department personnel, as well as external design engineers, 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 to convey general design guidance regarding electrical systems at Water and Waste Department facilities. This document addresses 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 shall use this guide as far as practical for new equipment, however in some cases compromise may be required to accommodate the configuration of the existing facility design and installation, which will be retained after an upgrade.

## 1.3 Document Revisions

Wastewater Planning and Project Delivery Branch (WWPPD) will issue revisions to the document on an as required basis. WWPPD will send out an email requesting review and comments by the division list below.

All proposed revisions shall be circulated to the following divisions and branches:

- Water Services Division
- Wastewater Services Division
- Solid Waste Services Division
- Engineering Division
  - Asset Management Branch
  - Design and Construction Branch
  - Drafting and Graphic Services Branch
  - Land Drainage and Flood Protection Branch
  - Wastewater Planning and Project Delivery Branch
  - Water Planning and Project Delivery Branch

After comments are incorporated into the finalized draft, WWPPD will send a copy of the approved PDF to the Business Communications Coordinator for upload to the Water and Waste Department Website.

## 1.4 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 |

| | |
| --- | --- |
| $H_2S$ | Hydrogen Sulfide |
| HMI | Human Machine Interface |
| HOA | 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 |
| MCC | Motor Control Centre |
| MCM | Thousand Circular Mil (old version – utilize kcmil for new projects) |
| MH | Metal Halide |
| MMC | Motor Management Controller |
| 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 |
| Unit Substation | As Defined in Section 6.13of this Design Guide |
| UPS | Uninterruptible Power Supply |
| UV | Ultraviolet |
| V | Volts |
| VA | Volt-Amperes |
| VAC | Volts Alternating Current |
| VDC | Volts Direct Current |
| VFD | Variable Frequency Drive |
| VRLA | Valve Regulated Lead Acid |
| WSTP | Winnipeg Sewage Treatment Program |
| XLPE | Cross-linked polyethylene insulation |

# 2 GENERAL

## 2.1 General Design Requirements

General design requirements are as follows:

1. All designs will comply with municipal, provincial, and national codes and bylaws.
2. All electrical systems, materials, and equipment will be of a type and quality intended for use in a permanent water or wastewater facility as appropriate. Industrial-grade design requirements apply.
3. The electrical systems will provide proper protection, continuity of service and a safe working environment.
4. All electrical systems and equipment will be designed and configured with due regard for the associated specific process and nature of installation. Standard commercial-grade practices will not be adequate unless specifically permitted in this design guide.
5. Designs will incorporate the principle that change will be a constant and inevitable fact within facilities. All systems will be constructed so as to facilitate this change while minimizing the cost of change and the amount of interruption to the operation of the facility. Electrical rooms, equipment and system control panels are to have extra space and provisions for future expansion.
   - 5.1 Designs will clearly demonstrate the concept for serving the future expansion. For example: future electrical distribution equipment should be shown dotted in the extra space in electrical rooms and spare capacities allowed for in the main equipment (transformers, diesel generators, UPS, and associated switchboards and panelboards) for the future expansion should be separately identified in the equipment sizing calculations.
6. Electrical systems and equipment will be designed and installed in a coordinated fashion. The design will take advantage of current best available proven technology and provide reliable electrical systems performance for the current project and into the future.
7. Unless approved by the City, 4160 V equipment will not be located below grade. This will include but not limited to:
   - 7.1 Transformers with primary voltage 4160 V or higher
   - 7.2 Switchboards
   - 7.3 Distribution Equipment
   - 7.4 VFD’s

## 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

In addition to any other City of Winnipeg standards, the following standards shall be used:

- 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 |
| 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

In addition, ensure all designs comply with the following standards:

| | |
| --- | --- |
| CAN/CSA C282 | Emergency Electric Power Supply for Buildings |
| CSA Z462 | Workplace Electrical Safety (Z462) |
| IEEE 1584 | Guide for Performing Arc–Flash Hazard Calculations (IEEE 1584) |
| IEEE 141 | IEEE Recommended Practice for Electric Power Distribution for Industrial Plants (IEEE 141, or the Red Book) |
| IEEE 241 | IEEE Recommended Practice for Electric Power Systems in Commercial Buildings (IEEE 241, or the Grey Book) |
| IEEE 242 | IEEE Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems (IEEE 242, or the Buff Book) |
| IEEE 399 | Recommended Practice for Industrial and Commercial Power System Analysis (IEEE 339, or the Brown Book) |
| IEEE 519 | Recommended Practice and Requirements for Harmonic Control in Electric Power Systems |
| IEEE 551 | IEEE Recommended Practice for Calculating Short–Circuit Currents in Industrial & Commercial Power Systems (IEEE 551, or the Violet Book) |
| IEEE 1015 | Recommended Practice For Applying Low Voltage Circuit Breakers Used in Industrial and Commercial Power Systems (IEEE 1015, or the Blue Book) |
| IEEE 1250 | IEEE Guide for Identifying and Improving Voltage Quality in Power Systems |
| ANSI / IEEE C37.10 | IEEE Application Guide for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis (IEEE C37.10) |
| ANSI / IEEE C37.13 | IEEE Standard for Low-Voltage AC Power Circuit Breakers Used in Enclosures (IEEE C37.13) |

### 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:

1. 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.
2. Arc flash energies are to be expressed in cal/cm$^2$
3. Motor power is to be expressed on all drawings and formal documents with both metric and imperial units. For example: 37 kW (50 hp).

## 2.3 Identification

All equipment shall be given an identifier that conforms to the latest version of the City of Winnipeg WWD Identification Standard. All equipment shall be identified on the drawings, documentation in the field and in software, where applicable, with the same identifier.

### 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. Where mechanically fastened lamacoids will compromise the enclosure rating ot the electrical equipment or are not practical adhesive such as 3M 467MP is allowable.
3. Apply lamacoids as per Table 2-1. Additional information shall be provided where required.
4. Provide warning and caution lamacoids in conformance with the latest requirements of the CEC. Lamacoids will have white lettering on a red background.

**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<br>Line 2: Load: Load Identifier<br>And if Load Identifier not clear:<br>Line 3: Load Description |
| Disconnect Switch - Separate | 5 mm | Line 1: Identifier<br>Line 2: Load: Load Identifier<br>And if Load Identifier not clear:<br>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<br>Line 2: Description (Optional)<br>Line 3: System Voltage<br>Line 4: Fed By |
| Motor Starter or MCC Bucket | 5 mm | Line 1: Load Identifier<br>Line 2: Load Description<br>And where applicable:<br>Line 3: One of # sources of electrical power (where more than one source of power feeds the equipment) |
| Panelboards | 8 mm<br>5mm may be used for space limitations | Line 1: Identifier<br>Line 2: Description (Optional)<br>Line 3: System Voltage<br>Line 4: Fed By |
| Protection Relays | 5 mm | Line 1: Identifier<br>Line 2: Description |
| Receptacles | 3 mm | Source Panel and Circuit Number |
| Switchgear | 8 mm | Line 1: Identifier<br>Line 2: Description (Optional)<br>Line 3: System Voltage<br>Line 4: Fed By |
| Switchgear Breaker or Switch | 8 mm | Line 1: Load Identifier<br>Line 2: Load Description |
| Transformer – Indoor | 8 mm | Line 1: Identifier<br>Line 2: Rating, System Voltage<br>Line 3: Fed By |
| Transformer - Outdoor | 10 mm | Line 1: Identifier<br>Line 2: Rating, System Voltage<br>Line 3: Fed By |

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# 3 DESIGN REQUIREMENTS

## 3.1 Service Conditions

1. Minimum requirements for service conditions applicable to all outdoor electrical installations are as follows:
   1.1 Minimum Temperature: -40°C
   1.2 Maximum Temperature: 40°C

## 3.2 Voltage Levels

### 3.2.1 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 may be dependent upon the utility.

Selection of a higher voltage over a lower voltage shall be utilized where:

1. The required current levels at the lower voltage are high (> 2000 A);
2. The utility is unable to supply the required power at the lower voltage; or
3. The potential arc flash energies at the lower voltage are at dangerous levels (> 40 cal/cm2).

## 3.3 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 registered in the Province of Manitoba. 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 cumulative 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 cumulative 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 kVA. |
| | 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 480 V 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.

### 3.3.1 Configuration A - 208/120 V

Configuration A, which is a simple system with 208/120 V 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 120/240 V service could also be considered where no significant motor loads are present. A single line diagram is shown in Figure 3-1.

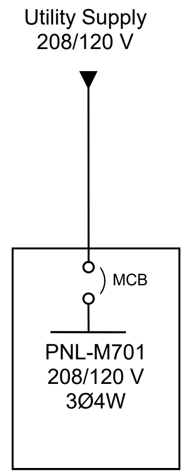


**Figure 3-1: Configuration A - 208/120 V**

### 3.3.2 Configuration B – 600 V Distribution

Configuration B, which is a simple radial system with a 600 V 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 600 V. While not shown on the sample drawing, additional 600 V panels or MCCs fed from the main distribution could be included with this configuration.

No redundancy, or standby generation, is provided by this configuration. While any power failure or equipment failure will result in an outage, operation is simple.

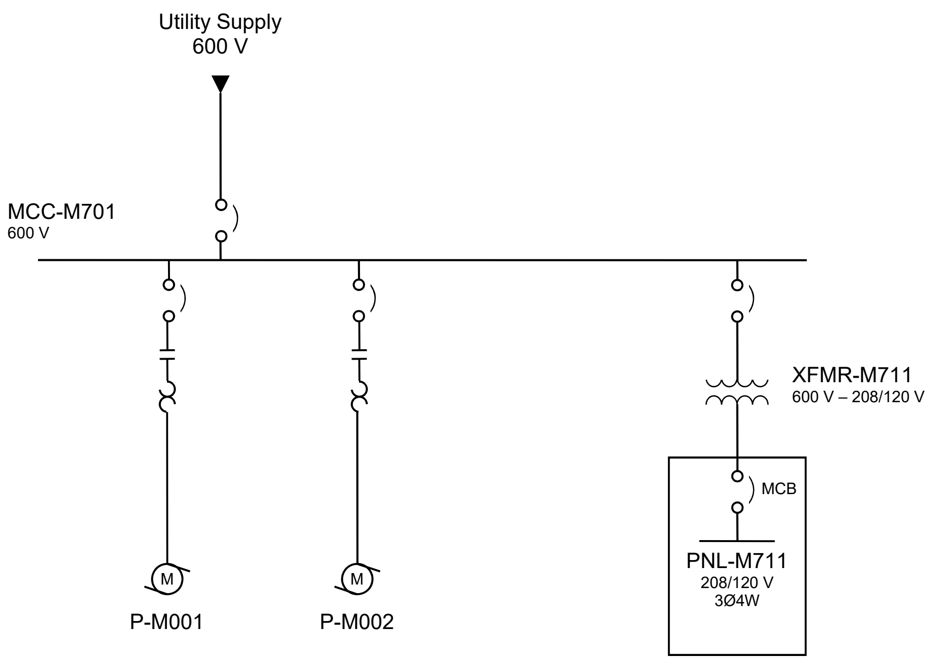


**Figure 3-2: Configuration B - 600 V Distribution**

### 3.3.3 Configuration C - 600 V 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 400 A of essential 600 V 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 may be considered when short term (< 3 hours) power failures are determined to be acceptable, but longer power failures are not.

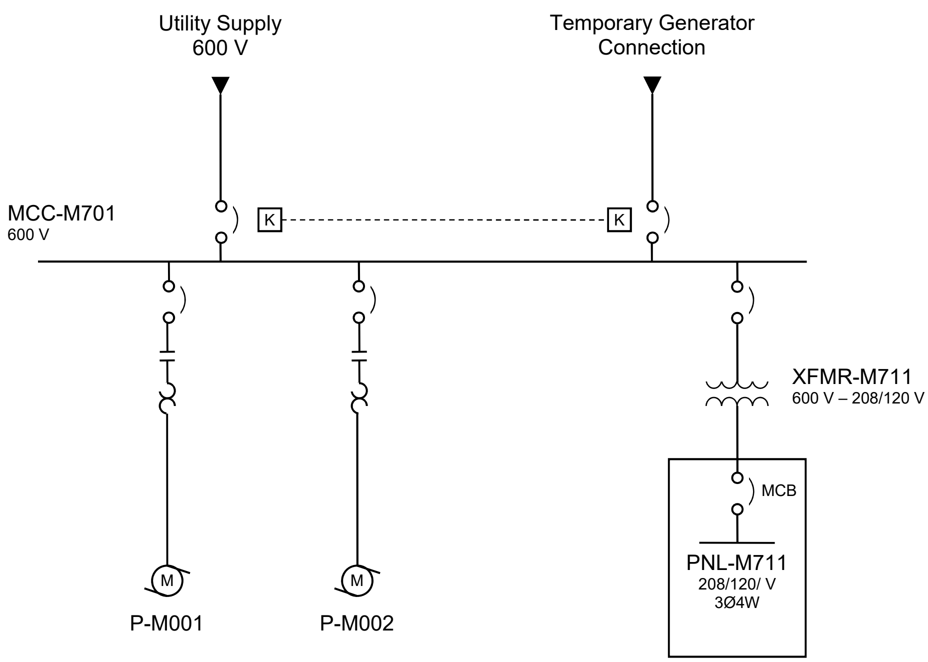


**Figure 3-3: Configuration C - 600 V Distribution with Portable Generator Provision**

*Note:*

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.

### 3.3.4 Configuration D - 600 V 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.

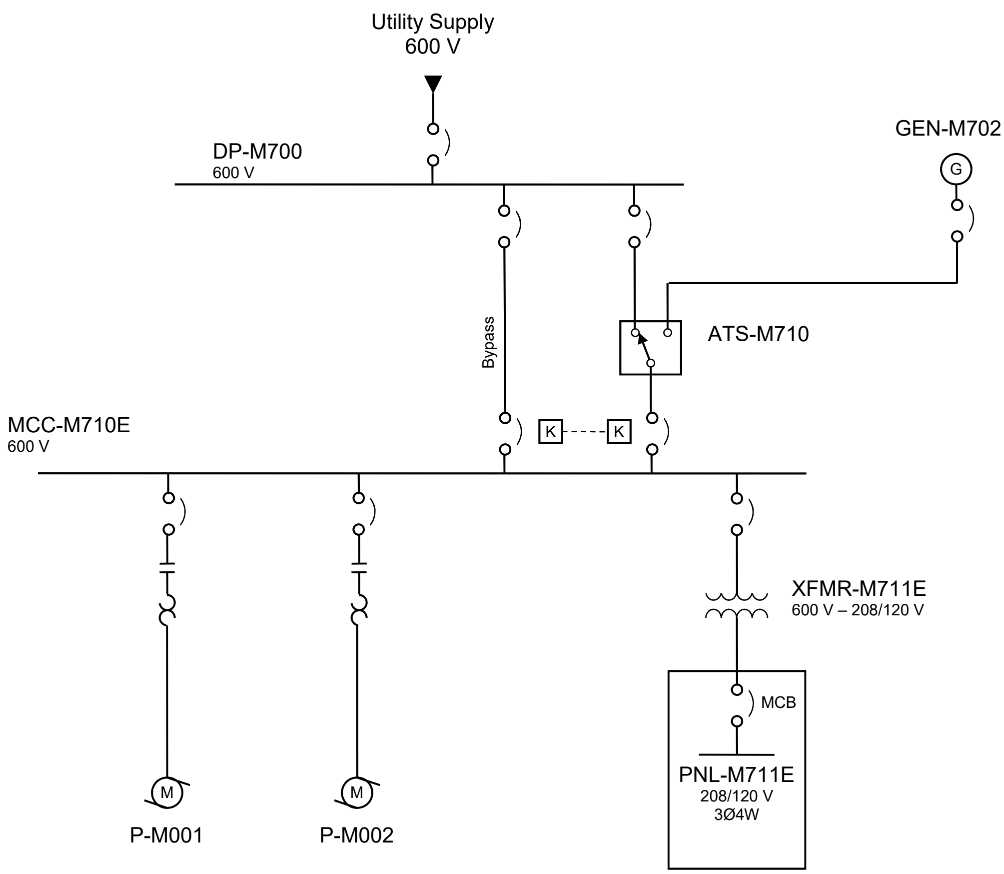


**Figure 3-4: Configuration D - 600 V Distribution with Standby Generator**

*Note:*

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.

### 3.3.5 Configuration E - 600 V Distribution with Essential Bus

Configuration E, 600 V Distribution with Essential Bus, is the same as Configuration D, 600 V 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.

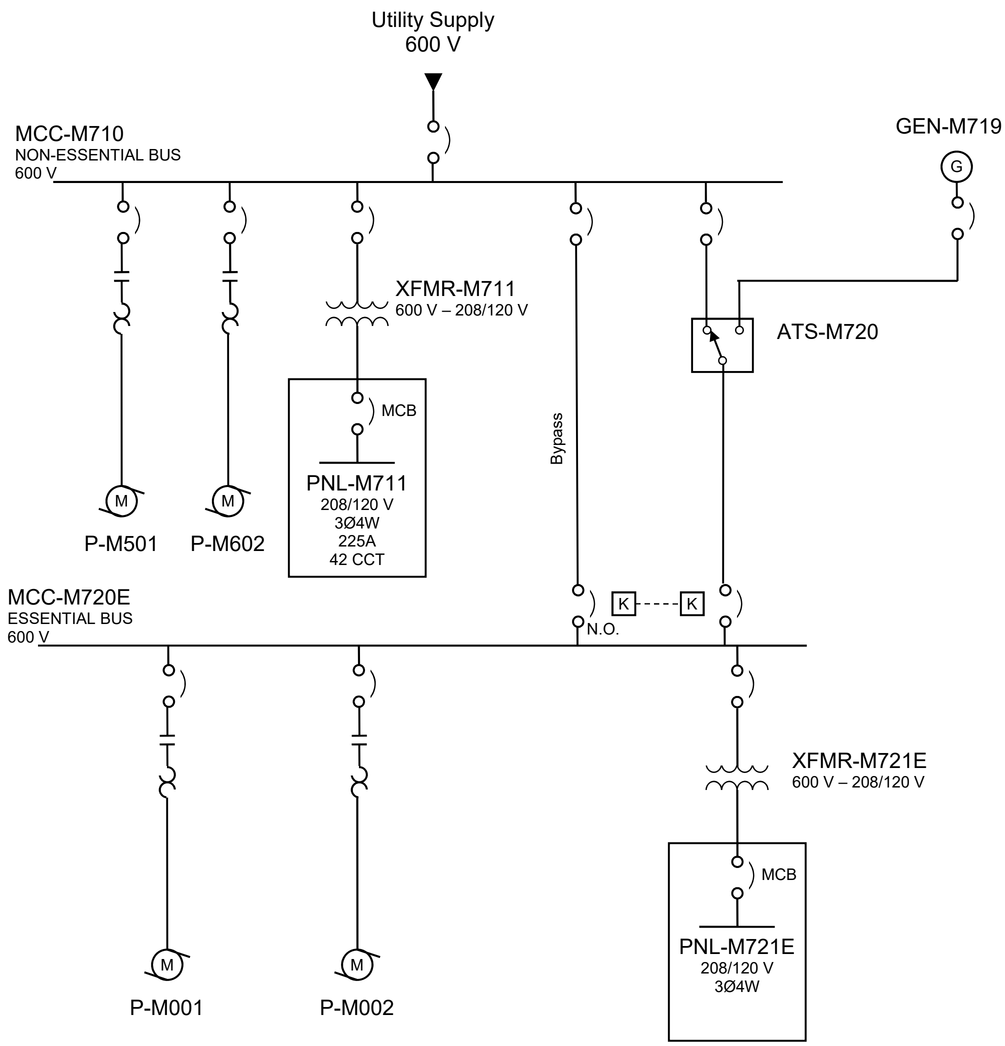


**Figure 3-5: Configuration E - 600 V Distribution with Essential Bus**

*Note:*

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

### 3.3.6 Configuration F - 600 V 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.

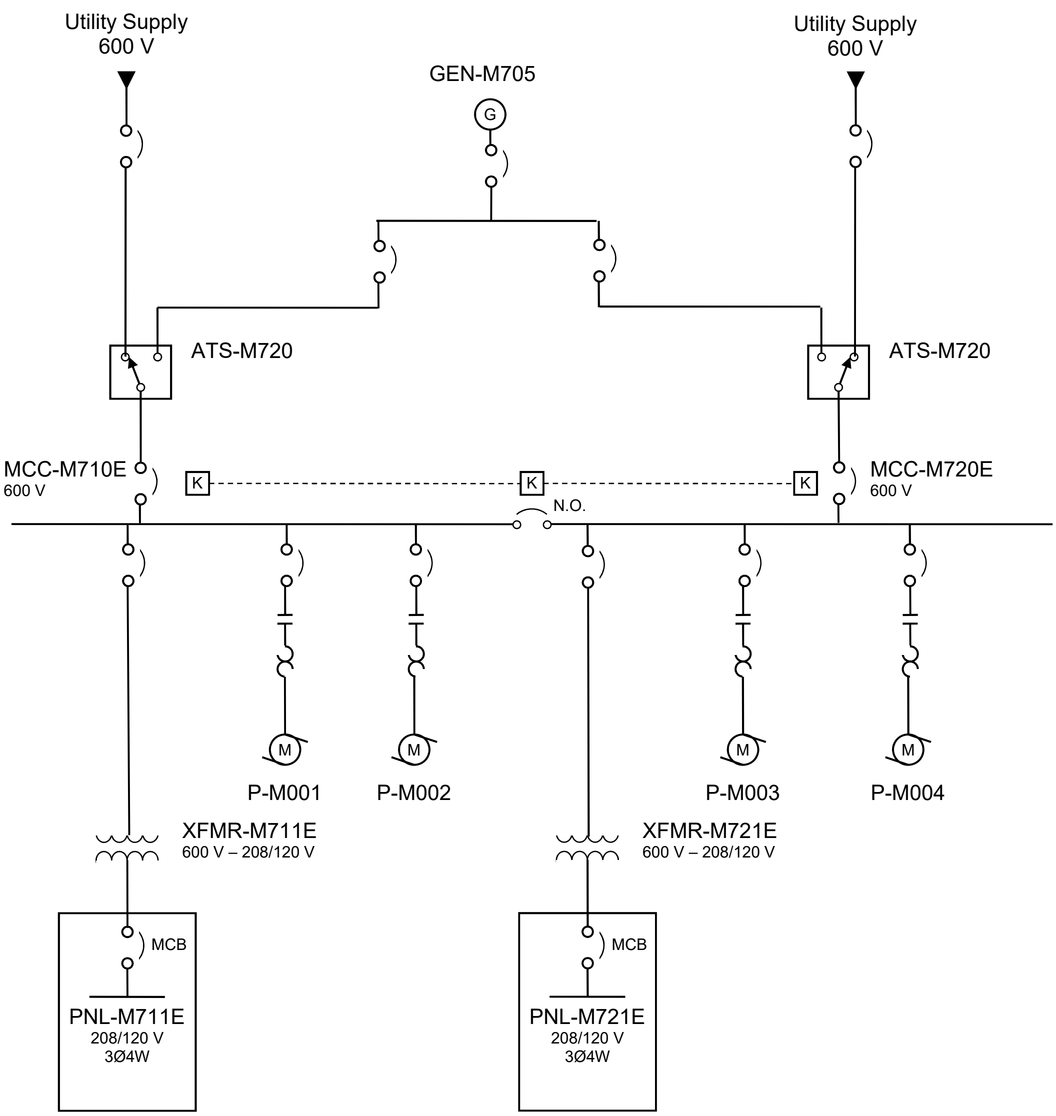


**Figure 3-6: Configuration F - 600 V Redundant with Standby Generator**

### 3.3.7 Configuration G - MV Distribution

Configuration G is a radial system with a medium voltage supply from the utility. Typically, transformation and utilization at 600 V and 208/120 V 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.

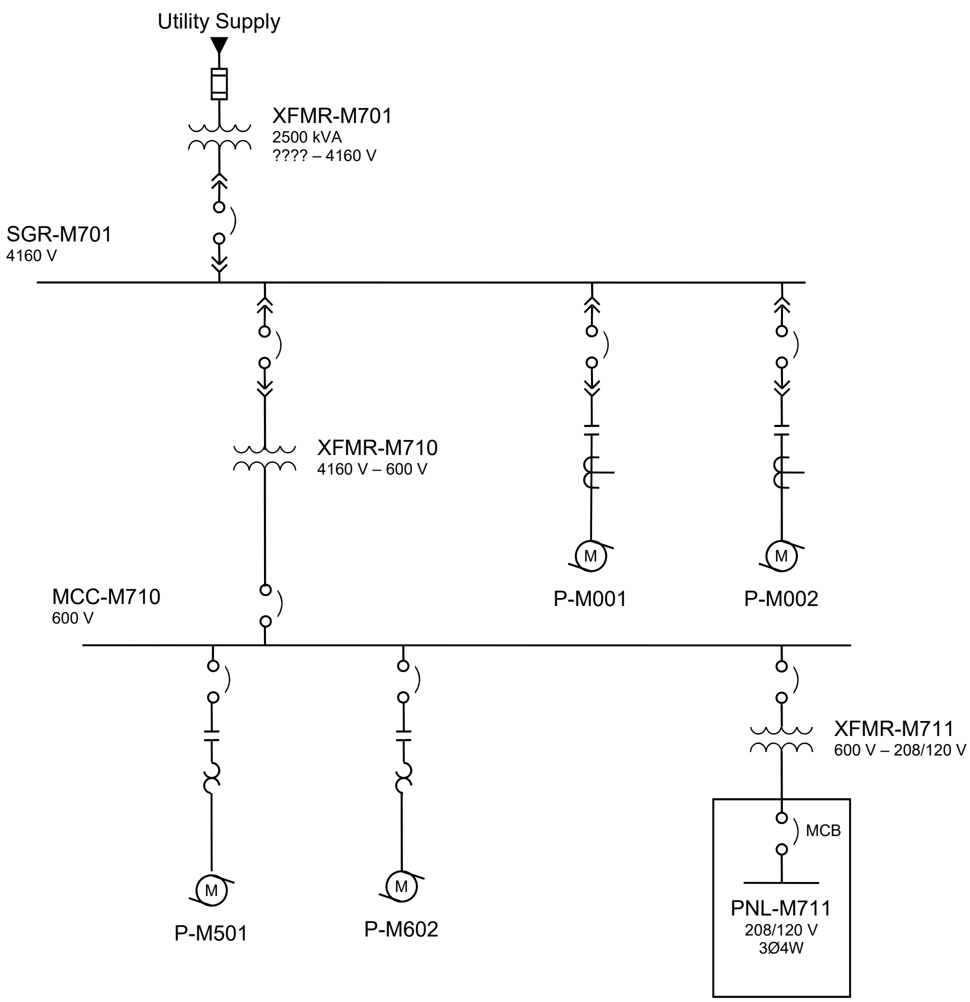


**Figure 3-7: Configuration G - MV Distribution**

### 3.3.8 Configuration H - MV Distribution with Essential Bus

Configuration H, MV Distribution with Essential Bus, is similar to Configuration E, 600 V Distribution with Essential Bus, except that medium voltage distribution is utilized in addition to 600 V 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 City-owned disconnect is required on the primary side of the transformer.

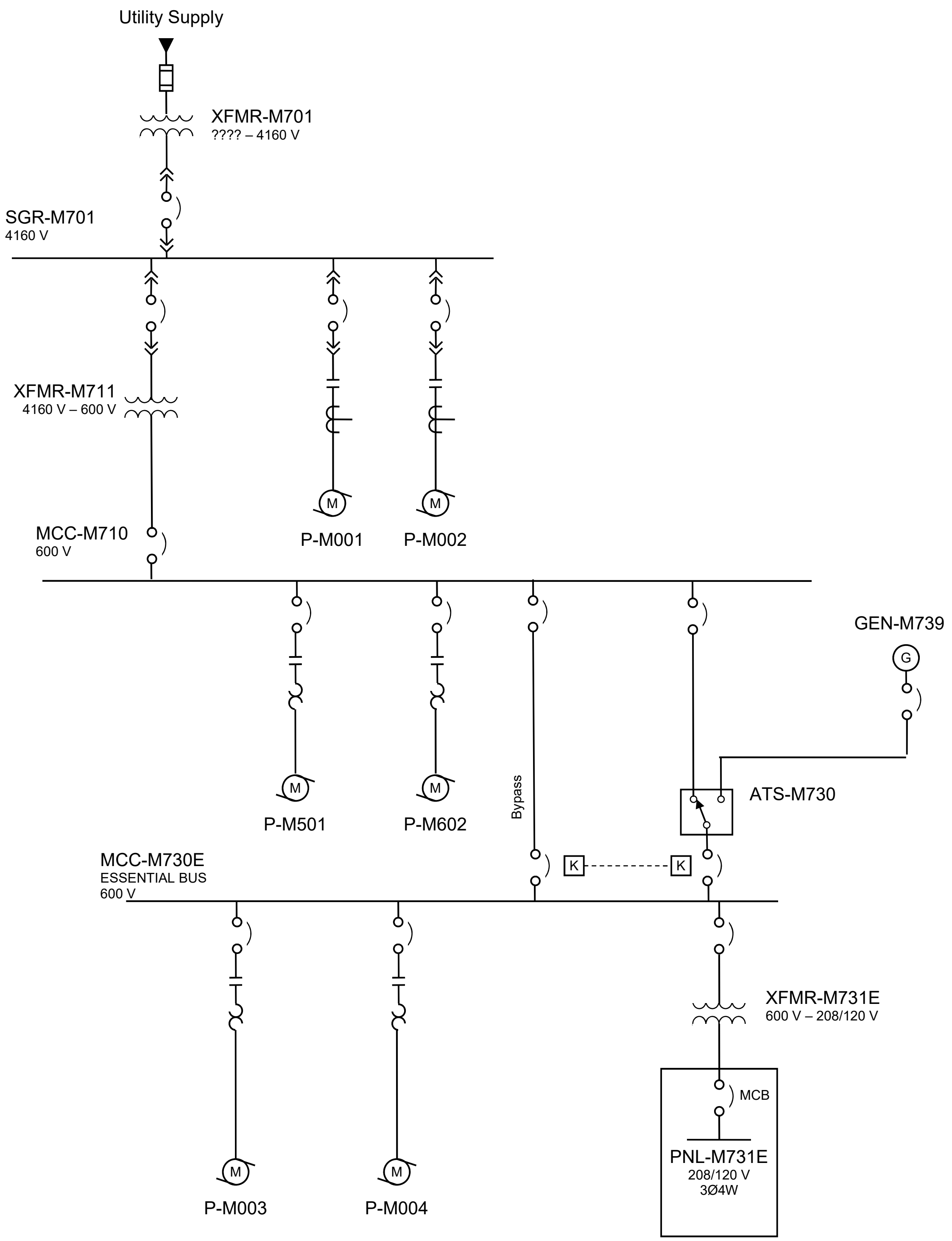


**Figure 3-8: Configuration H - MV Distribution with Essential Bus**

### 3.3.9 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 City-owned disconnect is required on the primary side of each transformer.

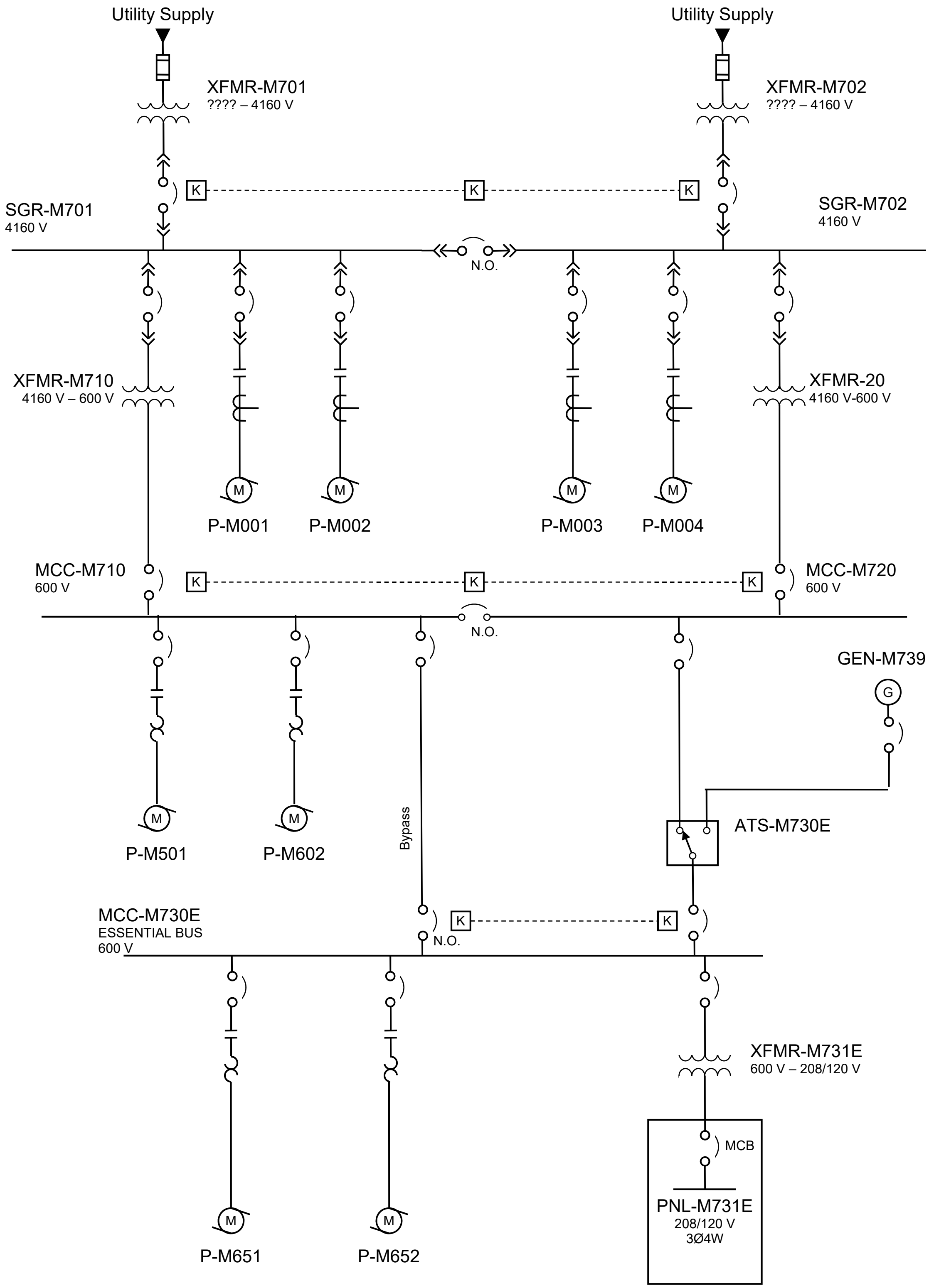


**Figure 3-9: Configuration I - MV Redundant with Essential Bus**

### 3.3.10 Configuration J - MV Redundant with Integrated Generation

Configuration J, MV Distribution with Integrated Generation, utilizes medium voltage for distribution and potentially motor loads. Generation is provided, with generator switchgear to allow for paralleling of generators and 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.

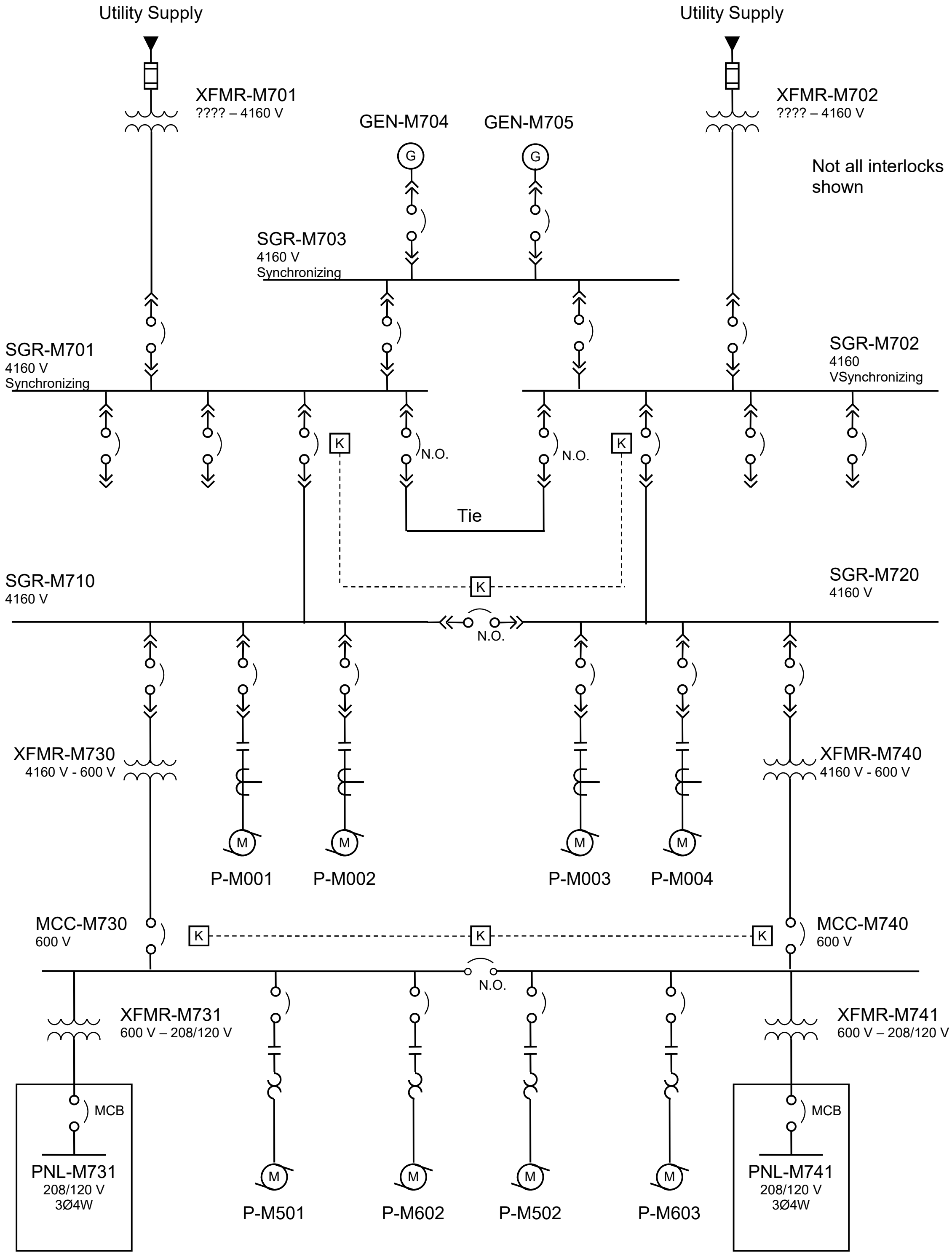


**Figure 3-10: Configuration J - MV Redundant with Integrated Generation**

### 3.3.11 System Configuration Selection

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 is required. Where selection of an appropriate system configuration is not clear, a reliability analysis shall be performed to aid in system selection.

**Table 3-2 : Preferred System Configurations**

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

*See Notes next page.*

*Notes:*

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 acceptance.
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.
7. The use of engine based backup drives could, with approval of the City, affect the requirement for standby generation or redundancy in a Land Draining Pumping Station or Wastewater Lift Station.

## 3.4 Redundancy Requirements

### 3.4.1 Wastewater Treatment Facilities

1. All electrical systems in a wastewater treatment facility shall be configured in a redundant manner such that the failure of a single piece of major equipment or major conductor will not impair the operation of the wastewater treatment facility. Without reducing the general requirement specified above, specific redundancy requirements are itemized in Table 3-3.

**Table 3-3 : Wastewater Treatment Process Redundancy Requirements**

| **Process** | **Capacity** | **Redundant Mandatory** | **Notes** |
| --- | --- | --- | --- |
| Incoming Electrical Service | All | Yes | |
| Raw Sewage Pumping Station | All | Yes | |
| Preliminary Treatment | All | Yes | |
| Primary Treatment | All | Yes | |
| Wet Weather Treatment | >= 100 MLD | Yes | |
| | < 100 MLD | No | |
| Secondary Treatment | Yes | Yes | |
| Tertiary Treatment | Yes | Yes | |
| Effluent Disinfection | >= 100 MLD | Yes | |
| | < 100 MLD | No | |
| Effluent Sampling | All | No | |
| Sludge/Biosolids | All | Yes | |
| Hauled Liquid Waste | All | No | |

2. The feeders to each redundantly configured piece of equipment shall be arranged in a manner to not defeat the redundancy of the arrangement.
3. Two-bank redundancy shall be utilized for medium voltage equipment.
4. Two-bank redundancy shall be utilized for low-voltage (< 750 V) equipment, except redundancy utilizing multiple banks will be permitted where the design capacity exceeds typical equipment ratings or the resulting arc flash energy of a two bank scenario is greater than desired/specified.
5. The capacity of two-bank and multi-bank redundancy schemes shall be such that the minimum capacity of each bank is the sum of any two bank loads that can be tied together, or 2xC/N, (where C is the Total Design Capacity (including spare) and N is the number of banks), whichever is greater. For clarity, with a two-bank scenario, if the total design capacity of a building is 1 MVA, then each redundant bank must have a capacity of 1 MVA.
6. Where multiple electrical rooms are utilized for a given process, given the distributed nature of the process, each electrical room shall be fed by a minimum of two banks of power complete with the appropriate interlocks (kirk key or similar), unless the electrical room has less than 100 kVA of load and there would be no consequences to the facility operation in the event of the electrical bank being out of service. An example of an electrical distribution for a distributed process is shown in Figure 3-11.

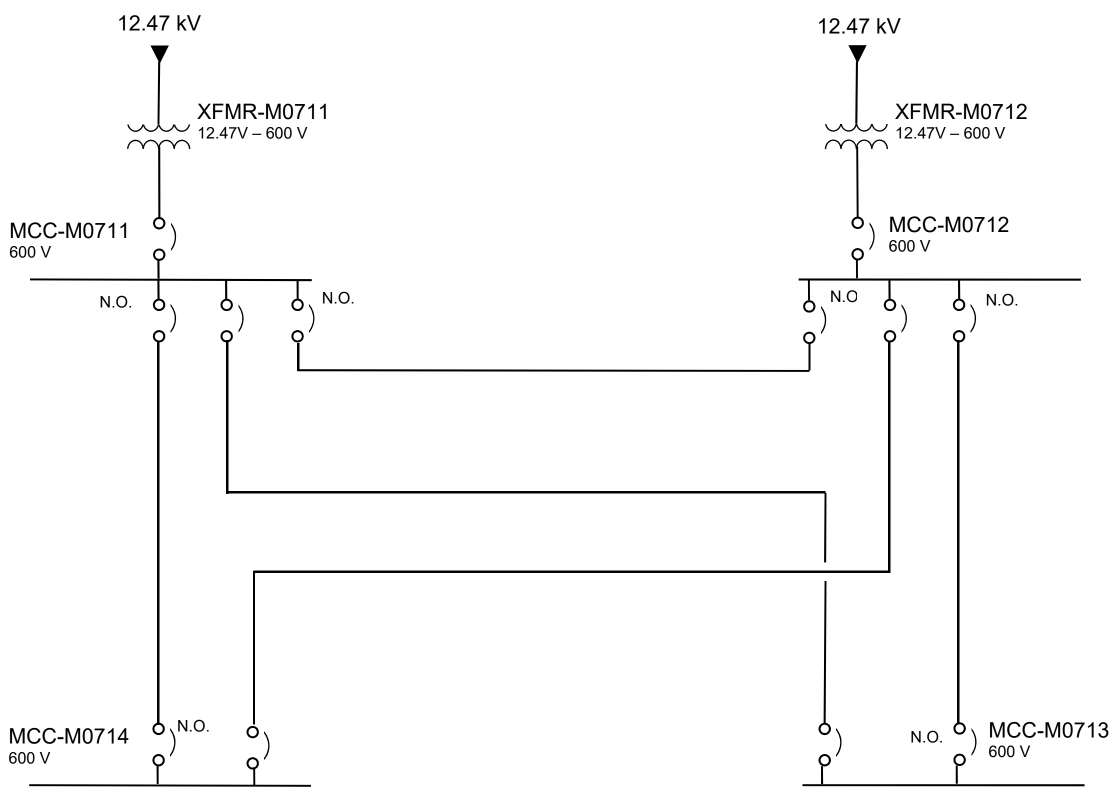


**Figure 3-11: Example of Distributed Process Redundancy**

## 3.5 Electrical Service

Electrical service sizing for new applications should be as shown in Table 3-4. Review potential future loads with the City and ensure that they are accommodated in the design. Deviations in the sizing of the electrical service are to be approved by the City.

**Table 3-4 : 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 + 15% 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 2) |

*Notes:*

1. Each of the redundant services would be sized to carry the full design load of the facility + 15%. Thus, under normal operation with two services, the total loading of the total capacity should not exceed 42.5%.
2. 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 (based on the total lifecycle costs), it is the City's preference to locate the point of delivery downstream of high and medium voltage transformation.

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; and
- Future growth.

## 3.6 Classification of Loads

### 3.6.1 Wastewater Treatment Facilities

| Priority | Description | Examples | Standby Power |
|---|---|---|---|
| 1 – Emergency | Life safety systems mandated by codes and regulations. (See Note 1) | Fire alarm and emergency voice communications systems;<br>Firefighters' elevators and elevators serving storeys above the first storey in a high building;<br>Fire protection water supply pumps that depend on electrical power supplied to the building;<br>Smoke control systems;<br>Fans required for smoke control;<br>Emergency lighting; and<br>Exit signs. | Yes |
| 2 – Critical | Loads that are critical for health and safety of facility occupants | Ventilation systems for electrically classified areas, hazardous gas detection systems | Yes |
| 3 – Essential | Essential loads required for process operation or infrastructure protection that cannot be interrupted. | Sump pumps, Raw sewage pumps | Yes |
| 4 – Essential Intermittent | Essential loads required for process operation, but may be interrupted for intervals during significant power events. | BNR aeration blowers | Yes |
| 5 – Normal A | Loads required for process operation that should not normally be interrupted, but may be under power failures and other extreme events. | BNR mixers | Not required |
| 6 - Normal B | Process loads that may be interrupted for significant abnormal events | Secondary clarifier mechanisms | Not required |
| 7 – Non-Essential A | Loads that may be interrupted with no significant impact on process, but may inconvenience personnel | General lighting, lunch room microwaves, general ventilation in non-hazardous areas. | Not required |
| 8 – Non-Essential B | Loads that may be interrupted with only minor inconvenience to | Task lighting, convenience receptacles | Not required |

| | | | |
|---|---|---|---|
| | personnel | | |

*Notes:*

1. The use of batteries in a life safety load does not change the load priority of the source. For example, a fire alarm system is a critical load.
2: From a load shedding perspective, additional levels are for adjustment of set-points and operating conditions prior to dropping a load.

## 3.7 Distribution Capacity

1. The size and capacity for new electrical distribution equipment and interconnections shall be as shown in Table 3-45. Review potential future loads with the City and ensure that they are accommodated in the design. Deviations in the sizing of the electrical distribution are to be reviewed and accepted by the City in writing.
2. Distribution systems may be considered dedicated (Dedicated Distribution Equipment) where:
   2.1 UNDER DEVELOPEMENT

Reference Transformer Section 6.11 in this Design Guide for additional information.

**Table 3-5 : Minimum Electrical Distribution Sizing**

| **Application** | **Application** | **Current Design Load** | **Future Design Load** (See Note a) | **Spare Capacity** |
|---|---|---|---|---|
| Medium Voltage | General | Required | Required | 25% |
| | Dedicated (See Note b) | | No (See Note c) | 10% |
| 600 V Switchgear | General | | Yes | Total design load + 25% spare on each service |
| 600 V MCCs | General | | Yes | Total design load + 25% spare on each service |
| | Dedicated (See Note b) | | | |
| Low Voltage Process Panelboards | | | No | Design load + 25% spare |
| | | | Yes | Total design load + 10% spare on each service (See Note b) |
| Low Voltage Building Panelboards | | | | |

*Notes:*

1. The Future Design Load is the planned future load that is anticipated to be planned for within the scope of the project. This typically includes planned future upgrades.
2. Despite the fact that Dedicated Distribution Equipment does not require future spare capacity, the building space, including electrical rooms, shall provide space as required to install future general and Dedicated Distribution Equipment.
   a) Each of the redundant services would be sized to carry the full design load of the facility + 15%. Thus, under normal operation with two services, the total loading of the total capacity should not exceed 42.5%.
   b) 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%.

3 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.

4 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.

## 3.8 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; and
- 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;
- System neutral is no longer at zero volts during a fault;
- Additional costs and complexities; and
- Additional monitoring, protection and coordination requirements.

System Applications:

1. 208/120 V Systems

   1.1 Solid grounding is mandatory.

2. 600 V (and 480 V if applicable) Systems:
   - 2.1 Systems < 1000 kVA would typically be solidly grounded, however high-resistance grounding (HRG) should be utilized 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 an L-G fault is desired.
   - 2.2 Systems >= 1000 kVA shall be provided with high-resistance grounding unless otherwise approved by the City.
3. 4160 V Systems
   - 3.1 High-resistance or low-resistance grounding is mandatory, except where:
     - a) The power supply from the utility is a 4160 V solidly grounded system; or
     - b) Express written permission is received from the City.
4. Medium Voltage Systems > 4160 V
   - 4.1 Low resistance grounding is mandatory for all medium voltage systems > 4160 V 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.

## 3.9 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 shall exceed the available fault current of the system, at the point of application of the device, panel or system and shall allow for future expansion of the system including replacement of transformers. For example, if a bus has a 23 kA SCCR requirements based upon an upstream 5.75% impedance transformer, but it is reasonably possible that the impedance of a replacement transformer could be 5%, size the SCCR of the bus based upon calculations using the 5% impedance. At a minimum the SCCR will be sized based on a +10% margin.

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 600 V 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 assumed SCCR values for unmarked components (i.e. with no SCCR rating) that may be assumed for calculations are as follows:

**Table 3-6 : Maximum 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 1250 V) | 10 |
| Receptacle (GFCI type) | 2 |
| Receptacle other | 10 |
| Supplementary protector | 0.2 |
| Switch Unit | 5 |
| Terminal Block | 10 |

## 3.10 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. Major points shall include but not be limited to:
   1.1 The main switchgear or electrical distribution in a building or process area of that voltage; and
   1.2 Switchgear / electrical distribution equipment rated greater than 3 MVA.
2. Voltage harmonics shall be limited as follows at all panelboards, MCCs, switchboards, switchgear, and other electrical busses:
   2.1 Individual frequency harmonics < 3%; and
   2.2 Total Harmonic Distortion (THD) < 5% as defied by IEC 61000-4-7.
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 19.4.
5. Refer to Section 15 regarding additional power quality requirements.
6. Comply with the latest version of the Manitoba Hydro's Power Quality Specification.

## 3.11 Environmental

Design / specify all electrical equipment, enclosures, etc. located outdoors for ambient temperatures of +/- $40^0$C. Ensure additional prevailing conditions, including humidity, accumulation and infiltration of snow and any environmental contaminants or conditions that could affect equipment performance and longevity are addressed in the design.

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.

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# 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). |

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

### 4.1.4 Examples

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

1. 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 8 kV 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 |
| 120/208 V | Solid | Any | 600 V |

*Note:*

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

# 4.4 Power Distribution

## 4.4.1 Conduits vs. Cables

1. Cables and conduits shall be selected based upon the requirements of Table 4-2.
   1.1 Where not identified in Table 4-2, 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 were the use of conduits is appropriate.
2. Conduits should be considered in the following applications:
   2.1 Where the existing installation is conduit based.
   2.2 Where aesthetics are a concern.
   2.3 Where there is potential for physical abuse or damage.
      2.3.1 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.
   2.4 Where the specific cables required do not have a FT4 rating.
3. It is acceptable for a facility to have a mixture of conduits and cables.

**Table 4-2 : Conduit / Cable Applications**

| Application | Voltage | Cable | Conduit | Notes |
| --- | --- | --- | --- | --- |
| Distribution | Medium Voltage | A | NA | 1 |
| | < 750 V | A | NA | 1 |
| Motor Loads | Medium Voltage | A | NA | |
| | 600 V | P | A | |
| | 208/120 V | A | A | |
| Heating Loads | 600 V | P | A | |
| | 208/120 V | A | A | |
| Other Equipment Loads | 600 V | P | A | |
| | 208/120 V | A | A | |
| Fire Alarm | < 750 V | A | A | |
| Lighting | < 750 V | A | P | |
| Receptacles | < =208 V | A | P | |
| | > 208 V | A | P | |
| Legend:<br>P Preferred<br>A Acceptable<br>NA Not Acceptable | | | | |

*Notes:*

1. Cable Bus is acceptable for distribution application.
2. Duct bus is acceptable only in clean, non-corrosive environments.

## 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

12.47 kV (15 kV Class) Distribution system:

CSA TECK cable, Tree-Resistant XLPE RW90, 15 kV, 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.

4.16 kV 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.

600 V, 208/120 V, 120/240 V Low Voltage Distribution system:

CSA TECK cable, XLPE RW90, 600 V/1000 V, 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, 600/300 V, with 100% insulation.

- 600 V cable is to be utilized for any cable termination in an enclosure containing voltages above 300 V.

Phase/polarity 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.

Fire Alarm Cable

- Cabling conforms to CAN/CSA-C22.2 No. 208 Fire Alarm and Signal Cable
- Low energy, 300 V, FAS 105 twisted stranded coper shielded cable: minimum 16AWG, with PVC insulation
- Overall aluminum/polyester foil shield, with tinned copper drain wire
- Notification circuit conductors shall be stranded copper, minimum 12 AWG
- All fire alarm cables shall be installed in a separate, dedicated conduit system
- All cables with be FT4 rated

## 4.6 Conductor Sizes

1. Select conductor size based upon conductor ampacity and voltage drop requirements.
   1.1 Voltage drop calculations shall be made utilizing worst case operating scenarios, including utilization of spare distribution capacity.
2. Ensure spare capacity allowed for in equipment is also provided in associated feeder conductor sizing.
3. 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.
   3.1 Unless specifically designated as a feeder cable tray, with a cable tray section layout clearly indicated on the drawings, all cable trays shall be assumed to have numerous cables added in the future and be de-rated appropriately.
   3.2 It is preferred to designate certain cable trays for large feeder cables, where spacing can be maintained.
4. 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.
   4.1 For example, if a motor feeder cable ampacity is calculated, based on a specific actual motor FLA, to be 258 A, do not select a cable with an ampacity of 260 A. In the event the motor is replaced with one that has a slightly higher FLA, the cable with an ampacity of 260 A would no longer be technically acceptable.
5. Ensure that the conductor sizes selected are appropriate for the maximum acceptable conductor termination temperature. For example, many circuit breaker terminations are only rated at 75°C and cannot utilize a conductor ampacity rating for a temperature rating of 90°C.
6. Minimum wire size to be as per Table 4-3.

**Table 4-3 : Minimum Conductor Sizes**

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

*Note:*

1. 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 4-4.
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 shall 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.
   - 6.3 All motors and connected equipment shall be considered to be a source of vibration.
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 19.4.

**Table 4-4 : 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 4-5. The widths of the prime and auxiliary bands are to be 38 mm and 19 mm, respectively.

**Table 4-5 : 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 | |
| Fibre Optic Cable | Purple | |

## 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 numbered terminals and the conductors shall be identified with wire labels.
3. Pull boxes should be sized as per the Canadian Electrical Code (Rule 12-3036).

# 4.10 Cable Trays

## 4.10.1 General

1. Arrangement
   1.1 Design cable trays in a manner to provide ease of access, capacity for expansion and change.
   1.2 Ensure headroom is not impeded by cable trays.
   1.3 Do not install cables for redundant systems in the same cable tray.
   1.4 Provide a minimum of 1 m separation (edge to edge) between cable trays carrying redundant cables or cables for redundant systems.
   1.5 Ensure cable tray routing does not impede equipment operation, maintenance or cable replacement;
   1.6 Locate cable tray in a manner and location to ensure the full life and reliability of the cables is maintained;
   1.7 Route such that the cable tray is not subjected to temperatures higher than ambient space temperatures; and
   1.8 Do not route cable trays above any combustible material storage.

2. Size:
   2.1 A side rail height of 152 mm (6”) is preferred. Utilize 102 mm (4”) side rail height where vertical space is limited.
   2.2 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 305 mm (12”) spacing. However for single conductor 1/0 to 4/0 AWG the rung spacing shall not exceed 229 mm (9”).
5. Tray load ratings:
   5.1 Cable tray load ratings are to be sufficient for the cables installed and any additional loads such as snow, ice and wind, where applicable.
   5.2 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.
   5.3 Minimum load rating for indoor tray: CSA Class C1
   5.4 Minimum load rating for outdoor tray: CSA Class D
6. The tray shall be installed in accordance with manufacturer’s instructions.
7. 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.
8. Use stainless steel SS316 bolting and fixing hardware.
9. Select cable tray material as per Table 4-6.
   9.1 Utilize fibreglass cable tray in corrosive locations where fibreglass will outperform the alternatives. Fibreglass tray shall not be exposed to sunlight unless confirmed by the manufacturer that it is sunlight/UV resistant.

**Table 4-6 : Standard Cable Tray Material**

| Application | Standard Material | Alternates |
|---|---|---|
| Wastewater Collection / Treatment | Aluminum | Fibreglass<br>Stainless Steel |
| Water Treatment Plant | Aluminum | Fibreglass<br>Stainless Steel |
| Regional Water Pumping Stations | Rigid Galvanized Steel | Aluminum<br>Fibreglass<br>Stainless Steel |

## 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. Provide additional depth below cables 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 4-7.
   - 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. Provide additional depth below conduits for critical applications.
7. Concrete duct banks (and utilidors):
   - 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.
   - 7.4 Pull boxes will be drained individually or use a connected network of drainage pipes. Pull boxes will be drained using:
     - 7.4.1 Connection to the land drainage infrastructure;
     - 7.4.2 Connection to a building’s sump pump system; or
     - 7.4.3 Connection to a pump station.
   - 7.5 All duct banks shall have a minimum of one duct allocated for fibre optic systems.
   - 7.6 Provide a minimum of 20% spare ducts.
   - 7.7 Ensure that the pull boxes are sized to account for minimum bending radius as per the Canadian Electric Code for both installation and long term use.
   - 7.8 All penetrations required in the pull boxes for cable entry/exits and pull box connections shall be included in the design.

7.9 The duct bank system shall be designed with a grade on each section of duct bank to prevent water from ponding in the ducts.

7.10 Pull boxes shall be watertight.

7.11 Pull boxes shall be mounted on appropriate foundations as required to prevent movement.

7.12 Pull tape shall be installed in all the ducts and shall be suitable for the highest applicable pull tensions.

**Table 4-7 : 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 < 750 V – Std. Reliability Requirement | Buried TECK Cable | |
| Low Voltage Power < 750 V – 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 (< 750 V)

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.
2. Materials shall be as per Table 4-8.

**Table 4-8 : 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 4-9. Note that typical good design practice would be to allocate a separate cable tray for power cables vs. instrumentation cables.

**Table 4-9 : Segregation of Cable Systems**

| Cable | Other Cable | Minimum Segregation | Notes |
|---|---|---|---|
| Communication - Fibre | Communication | None | |
| | Instrumentation / Control < 50 V | None | |
| | Other | Separate Raceway | To reduce risk of physical damage to fibre cable. |
| Communication - Copper | Instrumentation / Control < 50 V | 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 < 50 V | 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 < 50 V | 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 | |

## 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 wires / cables within the same conduit or cable tray is not acceptable.
4. Redundant medium voltage cables shall not be closer than 1 m at any point along the length of the cables.

# 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. Utilize industrial grade fixtures and components in process areas.
3. Refer to Table 5-1 for a general comparison of various fixture types.
4. Fluorescent or LED fixtures are preferred for most indoor applications as they provide instant on capability.
5. Light fixtures must be selected for the correct environment and installed (mounted) to facilitate lamp replacement and maintenance. Where corrosive gasses may be present, utilize sealed fixtures which are resistant to the specific corrosive atmosphere. Selection of accessories and other related materials must also bear the same degree of protection and be properly installed.
6. 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.
   6.1 Lifecycle costs of original price, lamp replacement, and energy use will guide the choice of lighting fixtures employed.
7. 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.
8. Select light fixtures to require minimal cleaning and permit practical and easy access and disassembly.

**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 | $ | |

*Note:*

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

**Table 5-2 : Lighting Fixture Types**

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

## 5.2 Lighting Control

1. Lighting controls shall be provided to reduce the energy consumption of the facility while minimizing impact on personnel.
   1.1 Requirements of the Manitoba Energy Code for Buildings may exceed requirements herein.
2. Design lighting control to permit simple and integrated control of lighting.
   2.1 Ensure lighting controls can be easily operated.
   2.2 Ensure lighting controls are conveniently located for each area and function.
   2.3 Provide capability to control lighting at each entrance to the space. Doors utilized exclusively as emergency exits are not required to have lighting controls.
3. Provide highly controllable lighting in control rooms with multiple lighting schemes to support day and night monitoring of HMI screens, meetings, cleaning and other functions without eye-strain to personnel. Scenes shall include but not be limited to:
   3.1 Full lighting on;
   3.2 Dimmed (50%);
   3.3 Dimmed + task lighting, zoned by working areas.
4. Provide highly controllable lighting in conference and meeting rooms with multiple lighting schemes to support meetings, A/V presentations, and video conferencing. Control of lighting will be integrated with the equipment controls and control stations in the room so as to permit the attendees to vary the ambient and task lighting as required for different activities. All conference and meeting rooms shall be provided with dimming down to 5%. Lighting will have minimum of four levels of control.
5. Where lighting controls are required to be located in areas accessible to the public, protect the controls from unauthorized operation.
6. Provide capability of overriding the night setback control.
7. All lighting controls shall be appropriate and appropriately rated for the area in which they are located. Commercial grade lighting controls are not acceptable within process areas.
8. In large open process areas, arrange and zone lighting controls to permit energy management control and variation of light levels. However, provide consideration to operational and maintenance requirements and ensure that the lighting control scheme does not negatively impact personnel.
9. Controls for lighting will be controlled utilizing a zone control of lighting. Zoning control to provide automatic night setback with sweep ‘off’ per programmable time (i.e. two hours) throughout the night to turn off lights that may have been manually turned on by staff via a local light control. Ensure safety considerations are addressed to avoid leaving staff in the dark through the use of warning or other appropriate mechanisms.
10. Lighting control system will be interfaced to the PCS to permit override ‘100% on’. Lighting program will be established to address different conditions such as power outage and fire alarm.
11. Where significant glazing is provided, utilize daylighting controls for all lighting in areas adjacent to exterior glazing and provide dimming to 10% of lamp output.
12. Occupancy sensors and, where provided, daylighting controls, will be integrated into the lighting controls.

13. Where always on and delayed off lighting is applied, more than one luminaire and more than one lighting circuit shall be used in each area to implement this strategy.
14. Refer to Table 5-3 for potential methods of lighting control. Note that the list is not exhaustive.
15. 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. |
| D | Dimmable | |
| 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 will turn off the lighting after occupancy is not detected for a set period of time. |
| OSM | Occupancy Sensor with Manual On-Off Switch | An occupancy sensor with a timer and a manual On-Off switch to override the occupancy switch. |
| 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/AO | 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 and the requirements of this document, whichever is greater.
2. Refer to Table 5-4 and Table 5-5 for required illumination levels for various applications.
3. Use the following criteria as maximum factors for calculation of illumination levels:
   3.1 Luminaire dirt depreciation: 0.80
   3.2 Luminaire lumen depreciation: 0.85
4. Where light fixtures may be subject to significant accumulating dust or splatter, utilize a lower luminaire dirt depreciation factor.

**Table 5-4 : Illumination Requirements - General**

| Area | Minimum / Average Illumination (lux) | Control (See Table 5-3) | Notes |
|---|---|---|---|
| Control Rooms | 400 / 450 | D +<br>OSM | |
| Corridors – High or Public Use | 200 / 250 | AO<br>TO/AO | |
| Corridors – Low Use | 100 / 150 | S<br>TO/AO | |
| Electrical Rooms | 450 / 500 | S<br>S/AO | |
| Electrical Shop | 500 / 550 | S | |
| Instrument Shop | 750 / 850 | S | |
| Janitor Rooms | 200 / 250 | | |
| Laboratory | –700 / 800 | D + OSM | |
| Locker Rooms | 150 / 200 | OS | Utilize ultrasonic or other appropriate technology to avoid lights turning off while in shower. |
| Mechanical (HVAC) Rooms | 200 / 250 | S<br>S/AO | |
| Offices | 450 / 500 | OSM | |
| Outdoor - Building Entrances | 75 / 100 | Photocell | |
| Outdoor Electrical Substations | 10 / 20 | Photocell | Base lighting |
| | 250 / 300 | S | . |
| Outdoor - Sidewalks and Walkways | 10 / 15 | Photocell | |
| Meeting Rooms | 450 / 500 | D + OSM | |
| Parking Lots | 20 / 25 | Photocell | |
| Process Areas - Indoor | 300 | S/AO<br>TO/AO | |
| Process Areas - Outdoor | 25 / 35 | Photocell | Walkways |
| | 150 / 200 | S | Or higher as required to operate and maintain the process |
| Roads | –10 / 15 | Photocell | |
| Server Rooms | 450 / 500 | OSM | |
| Stairways – High or Public Use | 200 / 250 | AO<br>TO/AO | |

| Area | Minimum / Average Illumination (lux) | Control (See Table 5-3) | Notes |
|---|---|---|---|
| Stairways – Low Use | 100 / 150 | AO<br>TO/AO | |
| Storage Rooms | 125 / 150 | OSM | |
| Washrooms | 150 / 200 | OS | |
| Workshop - Mechanical Maintenance | 500 / 550 | S<br>TO/AO | |
| General – Not Specified | 250 / 300 | TBD | May discuss with City |

**Table 5-5 : Illumination Requirements - Specific**

| Facility Type | Area | Recommended Illumination (lux) | Control (See Table 5-3) | Notes |
|---|---|---|---|---|
| Wastewater Lift Station | Main Level – Electrical Area | 300 - 350 | S<br>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<br>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 | |

## 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.
3. Locate fixtures to avoid the accumulation of dust and spatter so far as practical.

## 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, or a combination of battery supported emergency lighting with a standby generator, 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 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 5-6.

**Table 5-6 : Typical Emergency Lighting Requirements**

| Facility Type | Area | Recommended Emergency Illumination (lux) | Min. Duration (hours) | 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. | - | |

*Notes:*

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.

# 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 Section 6.10.
2. The voltage for switchgear DC power supplies shall be 125 VDC, 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 600 V, 3-phase. Alternately, 208 V, 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 (2-pole, 250 V DC) for 125 V DC load circuits. One breaker is 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 (2-pole, 250 V DC) for connecting the 125 V 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, in many cases labelled as the negative terminal, 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 required.
2. Ensure a high temperature cut-out is provided for electric heaters.
3. Ensure an airflow proving switch is provided for all forced air electric heaters.
4. SCR systems should be utilized for applications requiring proportional control. Zero-crossing SCR systems are preferred to reduce harmonics.
5. 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 600 V on a 600 V rated system, and not 575 V.
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 | Voltage Levels | Acceptable | Notes |
|---|---|---|---|
| < 1.5 kW | 120 V, 1Ø | Yes | |
| | 208 V, 1Ø<br>240 V, 1Ø | Yes | |
| | 208 V, 3Ø | Yes | |
| 1.5 kW – 4.9 kW | 24 , 1Ø | Specific Cases | Only where three phase power is not available |
| | 208 V, 3Ø | Yes | |
| | 600 V, 3Ø | Yes | |
| 5.0 kW – 9.9 kW | 208 V, 1Ø<br>240 V, 1Ø | No | Except with City approval due to extenuating circumstances |
| | 208 V, 3Ø | No | Except with City approval due to extenuating circumstances |
| | 600 V, 3Ø | Yes | |
| > 10 kW | 600 V, 3Ø | Yes | |

# 6.3 Motor Control Centres

## 6.3.1 Low Voltage MCC (600 V)

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 accepted by the City.
2. Enclosure Type: NEMA 1 with gaskets or better if the application requires.
3. Wiring Type: Class 1, Type B-D or B-T.
4. Busbars: Tin-plated copper.
5. Short circuit withstand rating is based on fault level calculations at the point of connections.
6. Provide thermographic inspection windows in MCCs (or compartments as applicable) with an arc flash rating of 8 cal/cm2 or greater.
7. Use surge arrestors at line terminals if MCC BIL rating is inadequate to meet system BIL requirements.
8. 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.
9. Utilize active harmonic filters or other harmonic mitigation means on MCC's that have VFD's or other harmonic sources as required to achieve a bus and incoming feeder harmonic level in accordance with Section 3.10.
10. Provide clearances around the MCC in accordance with Code requirements and the following, whichever is greater:
    - 10.1 Front of MCC: 1.5 m
11. As per Section 9.2 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.
    - 11.1 Power meters may be omitted for small applications, where approved by the City.
    - 11.2 Provide meter with harmonic voltage and current measurement capabilities where significant harmonics are present.
12. 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.
    - 12.1 Voltage relay to alarm on any phase loss or voltage imbalance > 10%.
    - 12.2 Voltage relay to automatically reset upon restoration of power.
    - 12.3 Standard of acceptance to be ABB SSAC WVM011AL.
    - 12.4 The voltage monitoring relay functionality may be combined with the power meter, provided all power failure modes are accounted for in the design.
13. All components shall be CSA approved or cUL listed.
14. Motor control circuits shall be 120 VAC and powered by a dedicated control power transformer within each motor starter.
    - 14.1 Size control power transformers with a minimum of 50 VA capacity above that required for starter components.
    - 14.2 Protect CPTs with two fuses on the primary winding and one fuse on the secondary. The secondary neutral shall be connected to ground.

15. 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

16. Ensure motor protection and control is consistent with Section 7

17. All motor overloads are to be of electronic type, to allow for improved protection, easier adjustment of settings, and better phase-loss protection.

    17.1 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.

18. 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.

    18.1 Apply smart/intelligent MCCs as per Table 6-2.

    18.2 Coordinate with the City to determine if the City has a current standard regarding manufacturer and/or communication protocol.

19. Drawing Requirements

    19.1 Provide a MCC Layout Drawing as per Section 19.2.10.

    19.2 Provide a MCC Schedule as per Section 19.2.11.

**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 | Yes | |
| Water Pumping Station | Yes | Yes | |
| Other | See Note 1 | TBD | Review on a case-by-case basis. |

*Note:*

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.
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. Provide thermographic inspection windows in all medium voltage MCCs.
11. Apply other design requirements from Section 6.3.1, as applicable.

## 6.4 Moulded Case Circuit Breakers

1. Protection Requirements:
   - 1.1 Provide electronic trip units with appropriate protection capabilities where required to meet protection, selective coordination and arc flash reduction requirements.
   - 1.2 All moulded case circuit breaker selection shall be based upon the Short Circuit, Coordination and Arc Flash Study as identified in Section 19.4.2.

## 6.5 Neutral Grounding Resistors

1. General Requirements
   - 1.1 All NGRs shall have an appropriate protection relay and be monitored locally (ammeter) and by the control system.
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 within 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. Refer to Section 10.5 for ground fault detection system requirements.

## 6.6 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. Except as noted in Subclause 3.1 below, utilize separate process panelboards from panelboards dedicated for building systems, each powered by separate transformers.
   3.1 Common process and building system panelboards may be utilized where the number of building circuits or process circuits will be less than eight, and there will be no operational or maintenance issues associated with the circuits being on a common panelboard.
4. Segregate loads such as those that generate high harmonics on a separate panelboard fed from a dedicated transformer.
5. Where 347V lighting is utilized, provide a dedicated 347/600 V panelboard powered by a transformer to generate the required neutral.
6. Provide a minimum of 20% spare 15A breakers (or 5 breakers, whichever is less).
7. DC panelboard shall be suitable for 125 V DC power and shall be rated either 125 V/250 V DC, 12/24 way distribution with individual DC rated circuit breakers. AC circuit breakers with equivalent DC rating are also acceptable.

# 6.7 Receptacles

## 6.7.1 General

1. Arrange receptacles in accessible locations, considering operational and maintenance requirements.
2. Ensure that the voltage drop is minimized such the maximum voltage drop at the receptacle utilization point is 3% below nominal voltage, under system full load.
3. Receptacles shall be coloured as per **Error! Reference source not found.**

**Table 6-3 : Receptacle Colours**

| Color | Application |
|---|---|
| White | General use – Offices, control rooms, and similar spaces |
| Grey | General use – Process areas, maintenance / shop areas |
| Orange | Powered by Process UPS |
| Blue | |
| Yellow | Powered by Lighting UPS |
| Red | Dedicated branch backed up by a generator and not load-shed. See Note 1. |

*Note:*

1. Where standby generator can power the main power distribution, only the receptacles always designated to be powered by the generators should be colored red.

### 6.7.2 Welding Receptacles

1. Provide 600 V, three-phase welding receptacles in areas where mechanical equipment will be maintained and where welding may be required. Welding receptacles will be 600 V, 3 Ø, 60 A with integral disconnect switch.
2. Supply a maximum of two welding receptacles from each feeder breaker.
3. Coordinate to ensure only a single receptacle type is provided for each facility.
4. Mount welding receptacles at 1.2 m.

### 6.7.3 Convenience Receptacles

1. Convenience receptacles are those allocated for undefined, general purpose use of facility occupants.
2. Convenience receptacles will be duplex 5-15 R, 120 V, 1-phase. Appropriate rated receptacles will be utilized in hazardous locations.
3. Locate convenience receptacles to include at minimum:
   - 3.1 Automation rooms: Every 3 m of wall space not completely blocked by equipment and on columns as required such that the entire space can be reached via a 3 m extension cord.
   - 3.2 Electrical rooms: Every 3 m of wall space not completely blocked by equipment and on columns as required such that the entire space can be reached via a 3 m extension cord.
   - 3.3 Control rooms: Every 2 m of wall space and at every workstation, desk, or other location where a convenience load may be required.
   - 3.4 Janitor rooms: Every 3 m of wall space.
   - 3.5 Mechanical rooms: Every 4 m of wall space and on columns as required such that the entire space can be reached via a 4 m extension cord.
   - 3.6 Server room: Every 2 m of wall space.
   - 3.7 Process areas (indoor and outdoor): Every 30 m of wall or walkway space.
   - 3.8 Other spaces: Every 6 m of wall space
   - 3.9 Areas within 7.5m of equipment requiring maintenance;
4. Limit the number of convenience receptacles on each circuit to a maximum of six duplex receptacles; however, ensure that receptacles that are likely to be simultaneously loaded are on separate circuits.
5. GFCI receptacles shall be provided for:
   - 5.1 All locations where required by the Canadian Electrical Code.
   - 5.2 All outdoor locations.
   - 5.3 All wet locations.
   - 5.4 All receptacles located below grade in a wastewater lift, flood station or wastewater treatment process area.

### 6.7.4 Maintenance Receptacles

1. Maintenance receptacles are those allocated for maintenance (and possible housekeeping) use.
2. Maintenance receptacles will be duplex 5-20R, 120 V, 1-phase and GFCI protected, except appropriate rated receptacles will be utilized in hazardous locations.
3. Locate maintenance receptacles in all indoor locations such that all floor areas can be reached with a 30 m extension cord.
4. Limit the number of maintenance receptacles on each circuit to a maximum of ten duplex receptacles; however ensure that receptacles that are likely to be simultaneously loaded are on separate circuits.
5.

### 6.7.5 Dedicated Purpose Receptacles

2. Utilize locking-type receptacles where:
   2.1 the receptacle or the connected device is subject to vibration; or
   2.2 the load is of high importance, including UPS, sump pumps, control equipment and emergency lighting.
3. Ensure dedicated purpose receptacles are on independent circuits, unless it can be clearly demonstrated that the loads are similar, and there will be no operational or maintenance impact through the use of a common circuit.

## 6.8 Soft Starters

### 6.8.1 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 600 V 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 6-4.

8. Where external contactors are utilized, IEC contactors shall only be acceptable in applications where internal bypass contactors are acceptable, as per Table 6-4. 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 6-4, 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 6-4.

**Table 6-4 : 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 in order to implement the automatic bypass starter.

### 6.8.2 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.
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.

### 6.8.3 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 Remote/Local 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.

## 6.9 Switchgear – Low Voltage

1. Switchgear connected directly to utility services must be service entrance rated.
2. Instrument Transformers
   2.1 Instrument transformers shall have a thermal rating of 2.0 and 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.

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. Provide closed-door racking for all low-voltage switchgear.

8. Provide arc-resistant switchgear or remote racking for switchgear with arc flash ratings exceeding 25 $cal/cm^2$ to limit the potential exposure of maintenance personnel performing racking operations.

9. Provide thermographic inspection windows in low voltage switchgear with an arc flash rating greater than 8 $cal/cm^2$.

10. Clearances

10.1 Provide sufficient working space in front of medium voltage switchgear to allow for all draw-out racking operations to be comfortably carried out by maintenance personnel. At a minimum provide 1.5m front clearance, in addition to space required for drawout equipment in the full disconnect position.

## 6.10 Switchgear – Medium Voltage

1. Switchgear connected directly to utility services must be service entrance rated.
2. The main incoming service for facilities requiring medium voltage switchgear shall be metal-clad circuit breaker switchgear.
3. Fuse-based medium voltage switchgear is only acceptable in the following scenarios:
   3.1 Systems without neutral-grounding resistors;
   3.2 Capacity is less than 2 MVA;
   3.3 Arc flash hazards are not increased by the use of a fuse based installation;
   3.4 Protection is provided to prevent the occurrence of a loss of a phase to loads; and
   3.5 Selective coordination is not lost.
4. Circuit breakers shall be vacuum circuit breakers.
5. Utilize 125 VDC switchgear control power for all installations, except as follows:
   5.1 AC control power may be utilized for installations less than 4 MVA, and requires provision of a dedicated UPS or capacitor trip supply.
6. At minimum, provide arc-resistant switchgear where the arc flash category level for the switchgear is above Category 2. Under no circumstances shall protection settings be set in a manner to reduce arc flash energies for the purpose of bypassing this requirement, if the reduced protection settings impact selective coordination or in any other way impact operation or maintenance.
7. Where arc resistant switchgear is provided:
   7.1 The standard of acceptance shall be ANSI/IEEE C37.20.7 Type 2B; and
   7.2 Ensure that the maximum fault clearing time is within the switchgear design limits (typically 0.5 second).
8. 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.
9. See Section 10.4 for protection requirements.
10. Provide at minimum the following signals to the control system for monitoring and alarming:
   10.1 Closed / open status of main and tie breakers.
   10.2 Breaker / Relay fail status.
   10.3 Metering signals as per Section 9.2.
11. Provide closed-door racking for all medium-voltage switchgear.
12. Consider the use of light-based arc detection protection relays to reduce arc flash energies.
13. Utilize remote racking for switchgear with arc flash ratings exceeding Category 3, where maintenance personnel are not otherwise protected by arc-resistant switchgear.
14. Ensure viewing windows are provided to visually monitor the position of disconnect blades in switch style switchgear.

15. Provide thermographic inspection windows in all medium voltage switchgear.

16. Clearances

    16.1 Provide sufficient working space in front of medium voltage switchgear to allow for all draw-out racking operations to be comfortably carried out by maintenance personnel. At a minimum provide 1.5m front clearance, in addition to space required for drawout equipment in the full disconnect position.

    16.2 Provide a minimum of 1 m clearance at the rear of the switchgear. Increase clearance in accordance with CSA 22.1 Table 56 as necessary.

    16.3 Provide a minimum of 1 m of clearance on the sides with radius around corners expanding to required clearances in the front and rear of the switchgear.

## 6.11 Transformers

1. General

    1.1 Provide 25% spare capacity for future use, except as follows:

        a) Where a dedicated electrical distribution is provided to power selected process loads in accordance with Section 3.7; or

        b) Where future loads are not expected and the City has approved the reduction of the spare capacity in writing.

    1.2 Percent Impedance (%Z) in accordance with CSA and design requirements.

    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. Sizing

    2.1 Ensure sizing is in accordance with Section 3.7.

    2.2 Ensure all transformer sizing is coordinated with generator sizing to allow the generator(s) to energize the transformer (considering maximum inrush current) without complicated start-up schemes.

    2.3 Limit the size of transformers in accordance with Table 6-5. Utilize separate transformers and secondary distribution systems where the size of the transformer is exceeded.

**Table 6-5 : Maximum Transformer Size**

| Secondary Voltage | Maximum Size (KVA) | | |
|---|---|---|---|
| | Distribution | | Service |
| | Recommended | Absolute | Recommended |
| 240/120 V, 1Ø | 50 | 75 | 30 |
| 208/120 V, 3Ø | 75 | 150 | 50 |
| 480 V, 3Ø | 1500 | 2000 | 2000 |
| 600 V, 3Ø | 2000 | 2500 | 2500 |
| 4160 V, 3Ø | 5000 | 5000 | 5000 |
| 12.47 kV, 3Ø | Note 1 | Note 1 | Note 1 |

*Notes:*

1. TBD

3. Outdoor, liquid-filled transformers

3.1 Efficiency in accordance with:

3.1.1 CAN/CSA C802.1 – Minimum Efficiency Values for Liquid-Filled Distribution Transformers

3.1.2 CAN/CSA C802.3 - Maximum Losses for Power Transformers

3.2 Secondary neutral terminal bushing is required. The neutral must be fully rated for all neutral grounding resistor applications.

3.3 Provide surge arrestors on the primary side of the transformer.

3.4 The NGR enclosure shall be stainless steel and NEMA 3-R rated.

3.5 Primary terminal bushings shall be suitable for cable connections.

3.6 Secondary terminals for connecting secondary cables or cable bus duct / bus way shall be tinned copper bus bars.

3.7 Utilize PCB free transformer oil suitable for Arctic conditions (extreme cold climate).

3.8 The transformer core shall be cold rolled grain oriented steel laminations.

3.9 Transformer shall withstand thermally and mechanically a two second short circuit at its secondary terminals.

3.10 Transformer shall be equipped with all standard metering, pressure relief and CTs as required by CSA.

3.11 Transformer shall be provided with stainless steel grounding pads at two diagonally opposite ends.

3.12 Transformer shall be equipped with oil fill, drain and sample valves.

3.13 Transformer shall be equipped with an oil level monitoring gauge with alarm contacts.

3.14 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.

3.15 Where Transformer connections are enclosed in junction boxes provide window for infrared thermography. Not applicable to pad-mount transformers.

3.16 Protection Requirements – Provide at minimum:

3.16.1 Primary and secondary overcurrent protection.

3.16.2 Winding temperature indicator with alarm and trip contacts.

3.16.3 Sudden pressure relay for sealed-tank design transformers.

3.16.4 Vacuum/pressure gauge for sealed-tank design transformers.

3.16.5 Provide differential protection for transformers as per Section 10.4.

3.17 Power transformers, >= 35 kV or >= 10 MVA:

3.17.1 Windings shall be disc type and not layer type.

3.17.2 Provide transformer demising partition walls between liquid-filled transformers that are in proximity to each other such as to affect the other during extreme events.

3.18 Provide a load-tap changer (LTC) where specified or required to provide acceptable voltage regulation.

3.19 Additional transformer protection is appropriate for many applications, especially for larger transformers. Apply protection in accordance with good engineering design practice.

4. Dry-Type Transformers

4.1 All indoor transformers shall be dry type unless otherwise specified or approved by the City.

4.2 Enclosure: NEMA 1 is typical. Specify NEMA 2 drip-proof or sprinkler-proof enclosure or NEMA 3R where required.

4.3 Efficiency in accordance with:

4.3.1 CSA C802.2 – Minimum Efficiency Values for Dry-Type Distribution Transformers

4.4 Ensure adequate space for ventilation is provided.

4.5 Provide at minimum two taps above and two taps below at 2.5% increments, full capacity.

4.6 Protection Requirements – Provide at minimum:

4.6.1 Primary and secondary overcurrent protection.

4.6.2 Winding temperature indicator with one probe in the center winding, with alarm and trip contacts for transformers >= 150 kVA.

4.6.3 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, 10 A, SPDT dry contacts for alarm and trip outputs. All contacts shall have an adjustable temperature setpoint.

4.7 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.

4.8 Review the requirement for K-rated transformers in harmonic environments.

4.9 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.

4.10 Ensure lifting hooks for lifting complete transformer assembly are provided.

4.11 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.

4.12 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.

4.13 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.

4.14 Provision shall be made for field installation of NGR current transformer on live side of NGR.

4.15 Protection for three-phase delta-wye transformers:

4.15.1 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.

4.15.2 For primary voltages > 750 V, protection may be either by fuse or circuit breaker, as appropriate for the application.

a) Ensure appropriate protection is provided to address transformer inrush and potential short circuit currents.

b) Ensure selective coordination is provided.

c) Refer to Section 10.4 for other protection requirements.

4.15.3 For primary voltages < 750 V, 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:

4.15.3.1 Transformer inrush current

4.15.3.2 Selective coordination between upstream and downstream breakers.

4.15.3.3 Transformer short circuit protection.

## 6.12 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.

## 6.13 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.

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.

## 6.14 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.

### 6.14.1 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.

### 6.14.2 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. Required voltage is 24 VDC.
   - 1.3 In larger facilities, the UPS will be designed to be multiple standalone units. 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 208/120 V UPS units shall be provided with an external maintenance bypass switch to allow for removal of the UPS unit.

### 6.14.3 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.

### 6.14.4 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 to be 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.

### 6.14.5 Battery Runtimes

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

**Table 6-6 : 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:**<br>N No Standby Generation<br>S Single Standby Generator or Generator System with No Redundancy<br>R Standby Generation with Generator Redundancy | | | | |

### 6.14.6 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 effect on standby generators.
2. Location
   2.1 Locate all UPS units above grade.
3. Environmental
   3.1 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%.

4. Ventilation

   4.1 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.

## 6.15 Variable Frequency Drives

### 6.15.1 General

1. Voltage of VFD drives shall be as per Table 6-7.

**Table 6-7 : VFD Voltage and Type Requirements**

| **Motor Power** | **Maximum Motor / VFD Voltage** | **Minimum VFD Pulse** (See Note 1) | **Notes** |
|---|---|---|---|
| < 224 kW (300 hp) | 600 V 3Ø | 6 | Small motors < 0.37 kW may be 120 V 1Ø |
| >= 224 kW (300 hp) and < 261 kW (350 hp) | 600 V 3Ø or 4160 V 3Ø | 12 | Dependant on application |
| > 261 kW (350 hp) | 4160 V 3Ø | 24 | |

*Notes:*

1. The minimum VFD pulse does not eliminate the requirement to meet Section 3.10 regarding harmonics, which may require a higher pulse count VFD.
2. Limit the length of VFD driven motor cables in accordance with Table 6-8.

**Table 6-8 : Maximum VFD Motor Cable Length**

| Motor Power | Maximum Motor / VFD Voltage | Maximum Length | | |
| --- | --- | --- | --- | --- |
| | | Normal Cases | Abnormal Cases (See Note 2) | Special Case With City Approval (See Note 3) |
| < 224 kW (300 hp) | 600 V 3Ø | 100 m | 150 m | 200 m |
| >= 224 kW (300 hp) and < 261 kW (350 hp) | 600 V 3Ø or 4160 V 3Ø | 80 m | 100 m | 125 m |
| > 261 kW (350 hp) | 4160 V 3Ø | 75 m | 100 m | 125 m |

*Notes:*

1. Do not assume that no harmonic or voltage mitigation is required for VFD motor cables less than or up to the indicated maximum length.
2. The length indicated for abnormal cases shall only be utilized for a limited number of motors where other practical alternatives do not exist. For example, a single VFD driven motor in a remote location could be classified as an abnormal case; however, a set of six 200 hp process pumps 145 m away from an electrical room would not be an abnormal case.
3. Special City approval shall only be utilized where it is demonstrated and clear that alternatives are not economically viable from a lifecycle cost alternative, and all appropriate filtering and other mitigation to address the long length is implemented.

## 6.15.2 Medium Voltage (4160 V) 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.

### 6.15.3 Low Voltage (600 V) VFD Requirements

2. 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.
3. 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.
1. Confirm that the building ventilation and cooling is adequate for the VFD heat loading.
2. Ensure that corrosive gases are not present in the VFD cooling air.
3. The system designer must review the harmonic impact of the VFD on the power supply.
4. 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.
   4.1 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.
5. Load reactors are utilized to protect the motor if the wiring distance between the VFD and motor is long.
   5.1 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:
      a) Load reactors are recommended for motors greater than 37 kW (50 hp) to reduce motor temperatures and increase motor life.
      b) Load reactors are recommended when motor leads exceed 30m.
      c) Load reactors are mandatory when motor leads exceed 100m.
      d) Filters (dv/dt) are required when motor leads exceed 150m.
6. Utilize inverter rated cabling for all six-pulse VFD load cabling, with three copper grounding conductors, 1000 V rated insulation, continuous copper tape shield with 50% overlap or continuous (non-interlocked) aluminum armour, and approved for six-pulse VFD use.

### 6.15.4 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 the VFD such that at any time only one can operate.
6. A zero speed switch or a suitable time delay relay will be used to prevent a bypass starter from closing power on a rotating motor.
7. 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.
8. Bypass mode is to be selected via a door-mounted two-position selector switch.

### 6.15.5 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
   - 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.

### 6.15.6 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 force main. 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 force main 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 force main. 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 Provide local manual speed control by means of a door-mounted potentiometer on the VFD panel.

# 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

1. The acceptable 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) |

*Notes:*

1. For motor sizes outside of the preferred ranges the designer shall submit to the City a clear rationale, with analysis as appropriate, justifying the deviation from the preferred range.
2. Motor sizes outside of the preferred ranges require specific acceptance by the City.
2. Three-phase motors are preferred over single-phase motors.
3. Utilize higher voltage motors where the higher voltage is available.

## 7.3 Special Requirements

1. The use of oversized terminal boxes is desirable. Size of power cable will have an influence on the size of the terminal box and must be taken into account. Terminal boxes must be accessible for the connection and disconnection of motors without dismantling or removing nearby equipment.
2. 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.
3. 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.

## 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:
     - a) Soft starter isolation contactors.
     - b) 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:
     - a) One size larger than required, or
     - b) 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 |
|---|---|---|
| 600 V motors, single speed, general service | < 75 kW (100 hp) | Electronic Overload |
| | >= 75 kW (100 hp)<br>< 187 kW (250 hp) | Overload<br>Overcurrent<br>Locked Rotor<br>Ground Fault (zero-sequence CT)<br>Winding Temperature (Thermistor or RTD) |
| | > 187 kW (250 hp) | Overload<br>Overcurrent<br>Locked Rotor<br>Ground Fault (zero-sequence CT)<br>Winding Temperature (RTD) |
| 600 V motors, single speed, critical service | < 37 kW (50 hp) | Electronic Overload |
| | >= 37 kW (50 hp)<br>< 75 kW (100 hp) | Electronic Overload<br>Winding Temperature (Thermistor or RTD)<br>Ground Fault (zero-sequence CT) |
| | >= 75 kW (100 hp)<br>< 187 kW (250 hp) | Overload<br>Overcurrent<br>Locked Rotor<br>Ground Fault (zero-sequence CT)<br>Winding Temperature (RTD) |
| | >= 187 kW (250 hp) | Overload<br>Overcurrent<br>Locked Rotor<br>Ground Fault (zero-sequence CT)<br>Winding Temperature (RTD)<br>Bearing Temperature |
| 600 V motors, VFD driven | < 37 kW (50 hp) | Standard VFD protection |
| | >= 37 kW (50 hp)<br>< 75 kW (100 hp) | Standard VFD protection<br>Winding Temperature (Thermistor - PTC) |
| | >= 75 kW (100 hp)<br>< 187 kW (250 hp) | Standard VFD protection<br>Winding Temperature (RTD) |
| | >= 187 kW (250 hp) | Standard VFD protection<br>Winding Temperature (RTD)<br>Bearing Temperature |

| Application | Rating | Protection |
|---|---|---|
| Medium Voltage Motor | <= 746 kW (1000 hp)<br>See Note 1 | Overload<br>Overcurrent<br>Locked Rotor<br>Ground Fault (zero-sequence CT)<br>Phase Balance<br>Undervoltage<br>Winding Temperature (RTD)<br>Bearing Vibration<br>Bearing Temperature |

*Notes:*

1. Medium Voltage motors greater than 746 kW will require, at minimum, the protection indicated, but in addition, shall be provided with additional protection as appropriate and in accordance with good industry practice.
2. Where bearing vibration and temperature sensors are required, they are required for each bearing.
3. Where PTC winding temperature is required, one detector shall be provided per phase.
4. Where RTD winding temperature is required, two RTDs are to be provided per phase.

## 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<br>Winding Temperature (switch) |
| | >= 75 kW (100 hp) | Humidity / leak (in applicable compartments such as connection housing / stator / oil)<br>Winding Temperature (RTD)<br>Bearing Temperature |
| | >= 186 kW (250 hp) | Humidity / leak (in applicable compartments such as connection housing / stator / oil)<br>Winding Temperature (RTD)<br>Bearing Temperature<br>Bearing vibration |

## 7.8 Local Controls

The following are 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)
        a) Install a *Hand-Off-Auto* (HOA) or *On-Off* switch and a green *Running* pilot light at the MCC/Starter, as appropriate.
    1.2 Pump motors (< 37 kW (50 hp))
        a) At the MCC/Starter, provide:
            i. A *Hand-Off-Auto* (HOA) switch
            ii. A blue *Ready* pilot light to indicate the motor is ready to run.
            iii. A green Running pilot light to indicate the motor is running.
        b) 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))
        a) At the MCC/Starter, provide:
            i. A Manual-Auto (M-A) and Start-Stop buttons
            ii. A blue Ready pilot light to indicate the motor is ready to run.
            iii. A green Running pilot light to indicate the motor is running.
        b) 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
        a) Install a *Soft Start / Bypass* switch at the starter.
2. Motor Driven Equipment - VFD Drive
    2.1 Pump motors (< 37 kW (50 hp))
        a) At the VFD starter, provide:
            i. A HOA switch.
            ii. A manual speed potentiometer to be utilized in Hand mode.
            iii. A blue Ready pilot light to indicate the motor is ready to run.
            iv. A green Running pilot light to indicate the motor is running.
        b) 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))
        a) At the VFD starter, provide:
            i. A *Manual-Auto* (M-A) and *Start-Stop* buttons
            ii. Install a manual speed potentiometer to be utilized in *Manual* mode.
            iii. A blue *Ready* pilot light to indicate the motor is ready to run.
            iv. A green *Running* pilot light to indicate the motor is running.
        b) 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:

a) Install a *VFD / Bypass* switch at the VFD starter.

*Notes:*

1. For motors > 50 hp, momentary start / stop is 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.
3. Additional safety controls may be required for equipment with safety requirements. An emergency-stop switch shall be a minimum requirement when there is a potential safety risk.

### 7.8.2 Wastewater Treatment Plants

1. Small motors (<= 19 kW (25 hp))
   - 1.1 At the MCC/Starter/VFD, provide:
     - a) A *Hand-Off-Remote* (HOR) switch.
     - b) A green *Running* pilot light to indicate the motor is running.
2. Motors (>19 kW (25 hp) and < 37 kW (50 hp)), standby operation
   - 2.1 At the MCC/Starter/VFD, provide:
     - a) A *Local-Off-Remote* (LOR) switch and *Start-Stop* pushbuttons.
     - b) A green *Running* pilot light to indicate the motor is running.
3. Medium size and larger motors (>= 37 kW (50 hp))
   - 3.1 At the MCC/Starter/VFD, provide:
     - a) A *Local/Off/Remote* (LOR) and *Start-Stop* pushbuttons.
     - b) A green *Running* pilot light to indicate the motor is running.
   - 3.2 Provide 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 shall 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 shall be a minimum requirement 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.

## 7.9 Local Disconnect Switches

The following are 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:
        - a) Install a local disconnect switch at the motor.
    - 1.2 Hazardous / corrosive location:
        - a) 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 (>= 37 kW (50 hp))
    - 2.1 Local disconnect switches will not typically be provided unless maintenance disconnect requirements are very frequent (more than weekly)
3. 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:
    - 3.1 VFD driven equipment; or
    - 3.2 Equipment that is utilized for standby operation and is critical to start when required.
4. Where a motor starter is local to the motor the disconnect may be included as part of the motor starter.
5. Hasps on 120 V panelboard breakers are not acceptable disconnecting means for motors.

*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 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:

1. 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.
2. 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.

# 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, the VFD 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, the VFD / motor starter 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 process exhaust fans shall always be located in electrical rooms.

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# 9 POWER SYSTEM MONITORING

## 9.1 Pilot Lights

1. 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 / Warning – Priority 1 - Process | Red | Amber | |
| Alarm / Warning – Priority 1 - Electrical System | Amber | Amber | See Note 3 |
| Alarm / Warning – Not Priority 1 | Amber | 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:*

1. 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. It is noted that these colors are different than much of the electrical industry and thus appropriate labelling and training is required.
2. Many existing systems within the wastewater facilities currently are based upon the colors indicated in the Water column.
3. The alarm / warning – Priority 1 color for electrical systems in wastewater facilities has been selected to be amber to avoid conflict with the switch / breaker closed status indication.

## 9.2 Power Meter Requirements

1. Multifunction power meters shall be provided as per Table 9-2.
2. Enhanced power meter requirements shall include:
   - 2.1 Local display for all measurements.
   - 2.2 Functional Requirements:
     - a) Volts, Amps, kW, kVAR, PF, kVA (per phase)
     - b) Frequency, kWh, kVAh, kVARh
     - c) Minimum 17 μs transient detection
     - d) Sampling rate of 1024 samples/cycle or better

2.3 Measurement Accuracy:

a) Power Class A monitor conforming to IEC 61000-4-30

b) 0.2% energy

c) 0.1% current

d) 0.1% voltage

e) Voltage and current harmonics measurement, individual, even, and odd, up to 63rd, %THD (Total Harmonic Distortion) Monitoring for voltage and current per phase.

f) Min / Max recording capability

2.4 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%).

2.5 The meter shall provide true RMS measurements of voltage, phase to neutral and phase to phase; current, per phase and neutral.

2.6 Ethernet Modbus TCP Communication capability, interconnected with the Ethernet Control Network, for communicating with the control system.

3. Basic power meter requirements shall include:

3.1 Local display for all measurements.

3.2 Functional Requirements:

a) Volts, Amps, kW, kVAR, PF, kVA

b) Frequency, kWh, kVAh, kVARh

c) % THD (Total Harmonic Distortion) Monitoring for voltage

d) 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. All power meters in wastewater treatment facilities shall be Schneider Electric.

5. Ensure the metering system is not dependent on power from the metered circuit for its operation. The power supply for the power meter shall be powered by a battery-backed power source, which ensures operation when the metered circuit is de-energized.

**Table 9-2 : Power Meter Requirements**

| Facility Type | Equipment | Advanced | Intermediate | Basic | Enhanced |
|---|---|---|---|---|---|
| All | Medium voltage main breakers - utility service | X | | | |
| | Medium voltage main breakers - not utility service | | X | | X |
| | Medium voltage feeder breakers. | | X | | X |
| | Medium voltage main switches of fused gear, unless the equivalent current reading can be provided by upstream feeders. | | X | | |
| | 600 V switchgear main breakers. | | X | | X |
| | 600 V switchgear feeder breakers rated 500 A 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 | X |
| | 600 V distribution panelboards rated 1000 A or greater. | | | | X |
| | 600 V distribution panelboards rated 400 A – 800 A or less than 400 A, but fed from a utility transformer or a transformer with a medium voltage primary. | | | X | |
| | MCCs with a connected load of 600 A or greater. | | | | X |
| | MCCs with a connected load of 250 A – 599 A or less than 250 A, but fed from a utility transformer or a transformer with a medium voltage primary. | | | X | |
| | Essential Power System – Main breaker / Distribution rated >= 500 kW | | | | X |
| | Essential Power System – Main breaker / Distribution rated >= 100 kW and < 500 kW | | | X | |

| Facility Type | Equipment | Advanced | Intermediate | Basic | Enhanced |
| --- | --- | --- | --- | --- | --- |
| | Essential Power System – 600 V distribution panelboards with a demand load of 200 A or greater. | | | X | |
| | Essential Power System – MCC with demand load of 100 A – 599 A | | | X | |
| | Generator – Medium Voltage | X | | | |
| | Generator – 600 V | | X | | |

## 9.3 HMI / SCADA Monitoring and Control Requirements

1. All enhanced power meters, as per Section 9.2 shall be connected to the HMI / SCADA system via a network connection.
   1.1 All key values including phase voltages, phase currents, kW, kVAR, PF, kVA and THD shall be available from the HMI, logged to the historian, and made available via trending.
2. Additional HMI / SCADA monitoring and control requirements of the electrical distribution system shall be provided 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 Ensure appropriate power fail status inputs are provided to allow for effective implementation of required control strategies.
   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 reasonable representation of power availability to controlled motor loads.

**Table 9-3 : Electrical Power System Monitoring and Control Minimum Requirements**

| Item | Monitoring | Control |
|---|---|---|
| Automatic Transfer Switch | Normal Position<br>Emergency Position<br>Common Fault | N/A |
| Breaker – High Voltage | Closed Status<br>Open Status<br>Breaker / Relay Fail Status<br>Local Status (Local/Remote)<br>Remote Status (Local/Remote) | Close Command<br>Open Command |
| Disconnect Switch – High Voltage, non-motorized | Closed Status<br>Open Status | |
| Breaker – Medium Voltage | Closed Status<br>Open Status<br>Breaker Rack Position Status<br>Breaker / Relay Fail Status<br>Control Power Fail (may be included in Fail status)<br>Local Status (Local/Remote)<br>Remote Status (Local/Remote) | Close Command<br>Open Command |
| Disconnect Switch – Medium Voltage | Closed Status<br>Open Status | |
| Breaker – 600 V >= 2000A | Breaker Closed Status<br>Breaker Open Status | Close Command<br>Open Command |
| Breaker – 600 V >= 600 A | Breaker Closed Status<br>Breaker Open Status | As required for load shedding strategy implementation. |
| Breaker – 600 V < 600 A | As required for load shedding strategy implementation. | As required for load shedding strategy implementation. |
| Capacitor / Power Factor Correction Bank | Alarm / Trouble | N/A |
| Neutral Grounding Resistor | Ground Fault Alarm | N/A |
| Motor Control Centre – General (specific requirements apply to MCC components) | Power Fail Status | N/A |
| Protection Relay – Medium Voltage | Alarm<br>Trip<br>Fail | N/A |
| Standby Generator | Auto / Manual Status or Local / Remote Status as applicable<br>Run<br>Trouble<br>Failure | Full Control |

| Item | Monitoring | Control |
| --- | --- | --- |
| Switchgear Battery System | AC Power Fail<br>DC Power Fail<br>Charging System Fail<br>High VDC<br>Low VDC<br>Positive Ground Fault<br>Negative Ground Fault | N/A |
| Transformers >= 1000 kVA | Temperature Alarm<br>Requirements of Section 6.11 | |
| Transformers >= 300 kVA | Temperature Alarm<br>Requirements of Section 6.11 | |
| TVSS | Status/Fault | |
| UPS | Battery Low<br>Fault | |

### 9.3.2 Additional Requirements for Wastewater Lift Stations

1. Provide voltage and phase loss monitoring for all incoming power distribution (600 V).
2. Provide 120 VAC power failure monitoring for all 120 VAC distribution systems.

### 9.3.3 Additional Requirements for Wastewater Flood Stations

1. Provide voltage and phase loss monitoring for all incoming power distribution (600 V).
2. Provide 120 VAC power failure monitoring for all 120 VAC distribution systems.

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# 10 PROTECTION

## 10.1 General

1. Design protection equipment so that the initial electrical installation, and future additions and modifications to the installation will be protected and fully coordinated, meaning that in the event of a fault or overload, protective devices will act to isolate only the faulty portion of the system and areas downstream, leaving all other portions of the system fully operational.
2. Ensure protection adequately protect against injury to persons and damage to property.

## 10.2 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 PT circuits. Potential transformer circuits shall be grounded on the secondary side.
4. Current transformer calculations shall be based on IEEE C.37.110 “Guide for the Application of Current Transformers Used for Protective Relaying Purposes” and take into account expected loading, short circuit levels, X/R values, and protective relaying burdens with a minimum thermal rating of 2.0..
5. Current transformers for medium voltage switchgear feeders shall be multi-ratio CTs.

## 10.3 Protection for Distribution <= 600 V

### 10.3.1 Circuit Breakers

1. Circuit breakers are required for 600 V distribution and below.
2. Ensure that circuit breakers are rated for the design SCCR at the specific point in the distribution.
3. Series breaker ratings are not permitted for the purpose of reducing the SCCR of downstream circuit breakers. All exceptions shall be accepted by the City. Ensure that the breakers selected provide selective coordination to the greatest extent possible. LS, LSI, and LSIG breakers shall be specified where required to achieve selective coordination. This may require the use of larger frame circuit breakers to achieve the required coordination.
4. Without limiting other requirements of this section, at a minimum:
   4.1 For breakers rated 600 A or greater, provide LSI or LSIG breakers;
5. Breaker and Protection Relay Settings Datasheets:
   5.1 For installations where the service rating is < 1000 kVA, indicate all breaker and protection relay settings on the drawings.
   5.2 For installations where the service rating is >= 1000 kVA, provide protection settings datasheets, divided by area code and equipment, that comprehensively indicate all breaker and protection relay settings.

### 10.3.2 Fuses

1. Fuses are acceptable in 600 V 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 protection of control power transformers or voltage instrument transformers.
2. Class J fuses are preferred for general purpose power use in new installations.

### 10.3.3 Ground Fault Protection

1. Provide ground fault protection for systems as follows:
   1.1 For systems rated 1000 A or more, ground fault protection is mandatory to de-energize all circuits.
   1.2 For systems rated less than 1000 A, ground fault protection at the main breaker is subject to City acceptance. However, the following should be noted:
      a) Ground fault protection should be provided where additional protection is required to reduce damage in the event of a ground fault.
      b) 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. Ground fault protection applied solely to the facility main breaker is not acceptable.
4. Where ground fault protection is provided, selective coordination of the ground fault protection shall be provided as follows.
   4.1 For essential power systems and systems feeding critical loads 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 accepted by the City.
   4.2 For all systems not addressed under 4.1 above, appropriate coordination shall be provided to limit the affected zone in the event of a ground fault trip
5. 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 by the City. There are applications 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 is capable of 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.

## 10.4 Protection for Medium Voltage Distribution

1. Circuit breakers are required in all medium voltage applications, except as follows:
   1.1 Protection of individual loads or transformers <= 2 MVA;
   1.2 Appropriate protection is provided to address potential single phase issues; and
   1.3 The resulting downstream arc flash energies are limited to Category 2 or lower.
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 shall be provided for all medium-voltage service 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.
   4.1 All installations of Undervoltage protection on main breakers shall be approved by the City.
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 installations with no redundancy;
   6.2 Transformers rated 7.5 MVA and above, for critical installations, with or without redundancy; and
   6.3 For all transformers rated 10 MVA and above.
   6.4 Differential protection for smaller transformers shall be evaluated on a case-by-case basis and reviewed with the City.
7. Provide zone/bus (IEEE 87Z or IEEE 87B) differential protection for indoor switchgear in a clean environment with a capacity of 10 MVA or greater and on outdoor switchgear or indoor switchgear not in a clean environment with a capacity of 7.5 MVA or greater.
   7.1 Zone/bus protection may be utilized to reduce the available arc flash energy to meet the requirements of Section 13.
8. Provide optical protection relays in switchgear where required to reduce arc flash ratings below 8cal/cm$^2$. Refer to Arc Flash Section in Appendix A

### 10.4.2 Ground Fault Protection

1. As discussed in Section 3.8, 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 and accepted by the City.

## 10.5 Resistance Grounding Ground Fault Detection Systems

### 10.5.1 Low Voltage/High Resistance Grounding

1. During the 1st phase to ground fault, the NGR system will:
   1.1 Alarm with both a local pilot light and an alarm to the PCS, allowing personnel to correct the problem or allow for an orderly shutdown of the process.
2. During the 2nd phase to ground fault, the protection system will:
   2.1 Trip the main breaker to de-energize the system.
3. Design the system to provide continuity of power upon a single ground fault event.
4. Provide a pulser-based system along with all required tools to allow maintenance personnel to diagnose and troubleshoot the location of the ground fault.

### 10.5.2 Low Resistance Grounding

1. Ensure all medium voltage ground faults trip the circuit breaker closest to the fault.

# 11 STANDBY AND EMERGENCY GENERATION

## 11.1 General Requirements

1. Generator ratings shall be selected based upon the ISO 8528 standard. ISO 8528 ratings are summarized as follows:
   - 1.1 Continuous Power
     - a) The rated output is available continuously, with average power output within 70% to 100% of the rating.
   - 1.2 Prime Power
     - a) 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
     - a) 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
     - a) 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 at the lowest point to drain condensation.
   - 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:
     - a) 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 weighed against the cost of providing diesel fuel storage and the associated diesel fuel ongoing supply and maintenance issues.

b) 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 $2/3^{rd}$ 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. Neutral Grounding Resistors:

8.1 Provide generator neutral grounding resistors as required to incorporate into the electrical design, but at minimum, should be provided for all generators rated 1 MW and over.

9. Automatic transfer switches:

 9.1 Provide ATS in compliance with CSA C22.2 No. 178.

 9.2 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.

 9.3 Most applications will utilize open transition transfer (break before make) for simplicity.

  a) Ensure that the open delay is sufficient for residual voltage of motor loads to dissipate.

 9.4 Closed transition transfer switches shall be provided when the facility cannot accept temporary power interruptions when transferring from the standby to utility source.

 9.5 Where closed transition transfer switches are required, selection is typically between three major types:

  a) Momentary Passive:

   i. 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.

   ii. The transfer switch must be CSA approved.

   iii. Under-voltage protection and an automatic synchronization check are required.

  b) Momentary Active:

   i. This type of transfer is the same as momentary passive discussed above, except that the generator is actively controlled by an automatic synchronizer.

  c) Soft Transition:

   i. 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.

   ii. This type of transition requires additional protection and coordination with the utility.

 9.6 Ensure that separate, interlocked bypass feeders are provided around automatic transfer switches to allow for maintenance on transfer switches without interrupting critical loads.

10. Load bank connection

 10.1 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.

  a) Unless the City has a portable load bank of the appropriate size, provide a permanent load bank for testing purposes.

 10.2 If not classified as an emergency generator, at minimum provide provision for connection of a temporary load bank subject to acceptance by the City.

11. Provide at minimum the following signals to the control system for each standby generator:

 11.1 Generator running

 11.2 Generator fail

## 11.2 Emergency Loads

Reference Section 3.6of this Design Guide

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:
     - a) Aircraft warning lights,
     - b) 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.

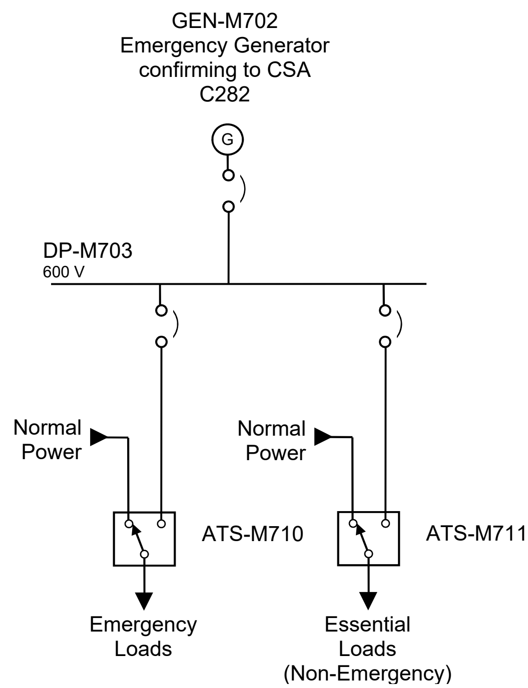


**Figure 11-1: Emergency Generator utilized for both Emergency and Essential Loads**

## 11.3 Essential Loads

Reference Section 3.6 of this Design Guide

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 designated 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.

## 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 responsible engineer and subject to acceptance by the City.
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 drip 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% spare (reserve) capacity.
    - 6.1 Where the generator is classified as an emergency generator, the 10% spare (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% spare (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. Transformer inrush: Ensure that upstream distribution transformers and generator sets are sized to handle transformer inrush 100% of the time without any issues, trips or alarms. Special generator start sequences, such as online reduced voltage generator starting, to reduce transformer inrush shall not be required. Where parallel generators are installed, ensure that transformer inrush can be met by 50% or N-2 of the generators running, whichever is greater. Provided that automatic, PLC controlled switching systems are installed to control the sequencing of loads on generator power, the generator installation may be designed to address the inrush of one transformer at a time. For any loads that do not have automatic sequencing, the transformer inrush loads shall be considered in parallel.
9. Design Load Calculations:
    - 9.1 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.
        - a) Three phase generators are rated for 0.8 PF. Lower power factors at rated kVA will require larger alternators.
        - b) 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.

9.2 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.

9.3 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.

9.4 Identify VFDs and non-liner loads with harmonic contribution to the generator voltage and current. Ensure that appropriate generation capacity is provided to address the harmonics present.

9.5 Review UPS loads to ensure sufficient generation capability is provided for charging current and harmonics.

9.6 After totalling all loads, add 10-25% to allow for future kVA capacity increase.

10. Regenerative loads:

10.1 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. Supply a junction box with terminals for temporary generator connection. 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.

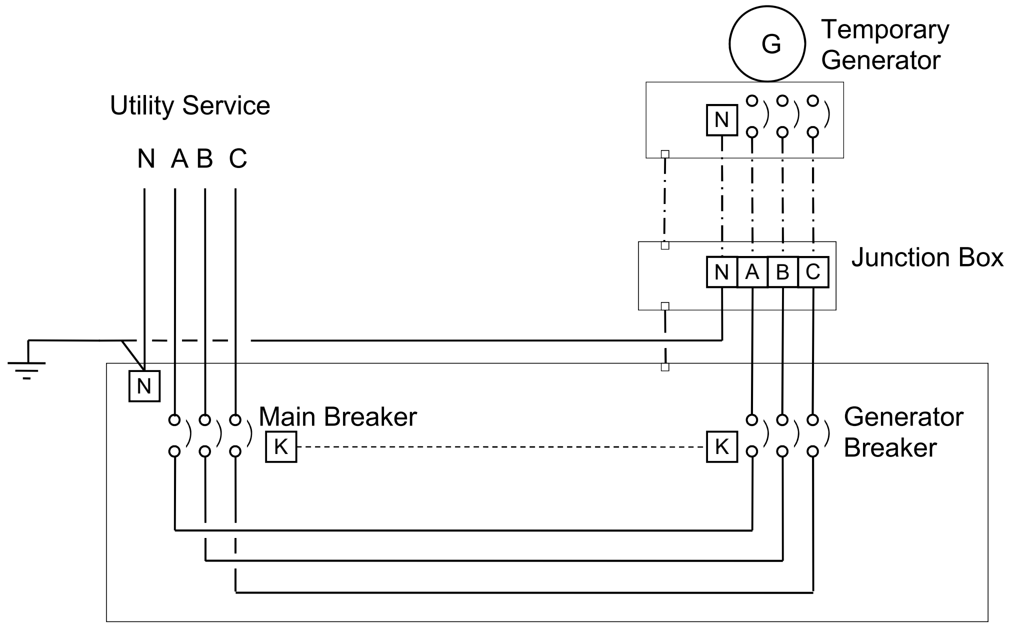


**Figure 11-2: Temporary Generator Connection - 3Ø3W**

*Note: The above assumes a grounded wye connected generator.*

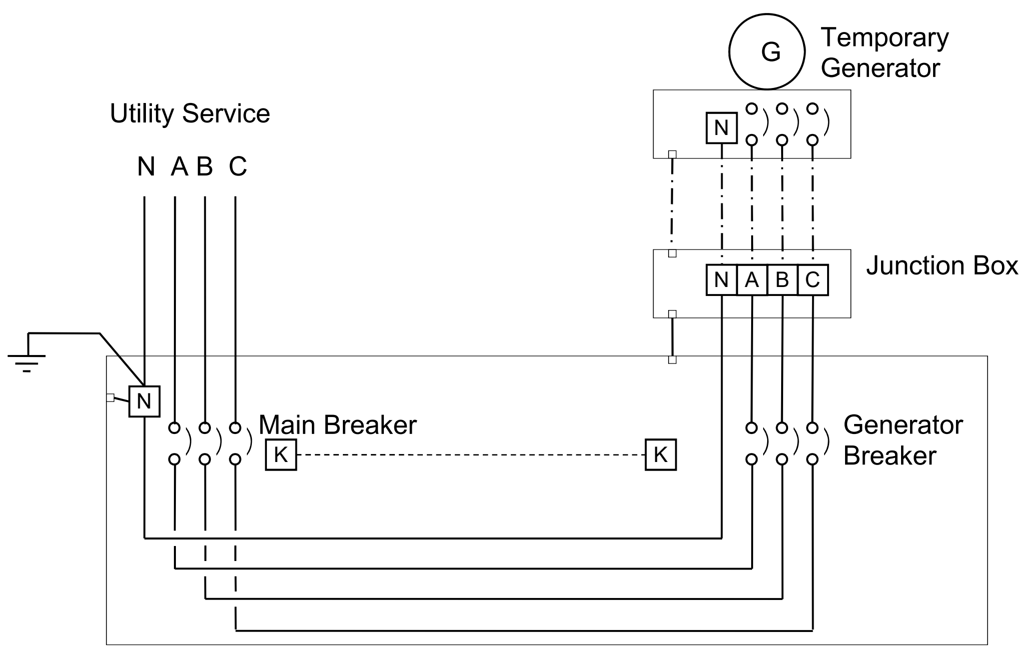


**Figure 11-3: Temporary Generator Connection - 3Ø4W**

*Note: The above assumes a grounded wye connected generator.*

# 12 HAZARDOUS LOCATIONS

## 12.1 General

1. Prepare comprehensive hazardous location drawings for all facilities containing a hazardous area, in accordance with Section 19.2.7.
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:
     - a) Approved for equipment protection level Ga (IEC);
     - b) 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.

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:

a) Approved for Class I or Class I, Div. 1 locations;

b) Approved for equipment protection level Ga or Gb (IEC);

c) Approved as being intrinsically safe, type i, ia, or ib;

d) Approved as being flameproof (marking “EEx d”);

e) Approved as being increased safety (marking “EEx e”);

f) Approved as being oil immersed (marking “EEx o”);

g) Approved as being pressurized (marking “EEx p”);

h) Approved as being powder filled (marking “EEx q”); or

i) Approved as being encapsulated (marking “EEx 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 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:
     - a) Non-arcing connections and connecting devices like joints, splices, etc. (non-sparking type)
     - b) Load break isolating switches interlocked to load break contactor or breaker.

c) Not more than ten sets of approved fuses; or

d) 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).

a) Any single conductor metallic armoured cable in Zone 2, carrying > 400 A is a possible ignition source due to high magnetic field and consequent energy available in the cable:

i. 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.

ii. 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 incendive source for ignition.

iii. A separate bonding conductor in parallel with the cable is required to bond both ends of the cable route, at the two enclosures.

2.10 It is preferred to use 3 conductor power cables with balanced loadings on all three conductors to cancel out the magnetic effect on armour.

2.11 Cable trays can be used in Zone 2 locations, however they should be bonded to prevent occurrence of circulating currents.

2.12 Conduits shall be sealed when crossing Zone 2 boundaries to prevent migration of gas vapours into other areas.

2.13 Electrical equipment that can be used in Zone 2 shall be:

a) approved for Class I, Division 2 locations;

b) approved as non-incendive;

c) approved as providing equipment protection level Ga, Gb, or Gc;

d) approved as providing a method of protection “n”; or

e) equipment permitted in Zone 1.

2.14 Ensure equipment temperature code classification is appropriate for the installation. See Table 12-1.

2.15 Ensure that equipment is suitable for the applicable gas group.

2.16 Increased safety e motors shall incorporate thermal protection.

2.17 Lighting fixtures shall be provided with guards to prevent breakage damage or be break resistant construction.

# 13 ARC FLASH HAZARD STUDY

## 13.1 General

Refer to Appendix A - Arc Flash Hazard Study and Electrical System Modeling Requirements

The purpose of an Arc Flash Hazard 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. The available arc flash energy information is identified on a label, which is to be applied to each piece of electrical equipment. Safe working guidelines and PPE requirements are referenced to these labels.

The Arc Flash Hazard Study 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 to specify equipment interrupting and withstand capacities. 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 and accepted by the City at design time so as to identify and mitigate any potential issues.

The City has standardized on Power*Tools software provided by SKM Systems Analysis, Inc. (also known as SKM PTW). 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 of Winnipeg WWD Identification Standard. The SKM PTW project and library files shall be supplied to the City, in native electronic format, upon completion of the Arc Flash Hazard 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, <= 600 V | 0 | 1 | |
| Distribution Panel, <= 600 V | 2 | 3 | |
| Distribution Panel, <= 600 V, Main Breaker | 3 | 4 | 2 |
| Motor Control Centre, 600 V | 2 | 3 | |
| Motor Control Centre, 600 V, Main Breaker | 3 | 4 | 2 |
| Panelboard, 208/120 V | 0 | 2 | |
| Panelboard, 347/600 V | 1 | 2 | |
| Switchgear, <= 600 V | 3 | 4 | |
| Switchgear, <= 600 V, 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.

The arc flash label format used for equipment rated Category 0 through Category 4 is shown in Appendix A Figure 2.9-1 and Figure 2.9-2.

# 14 GROUNDING

## 14.1 General

1. See Section 3.8 for system grounding requirements.
2. Reference IEEE-142 and IEEE-399 for grounding system design practices.
3. All grounding and bonding are to utilize stranded 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:
   - 5.1 600 V 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:
   - 6.1 600 V 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 (< 750 V)

1. All major electrical equipment rated 1200 A and above, such as transformers, switchgear, large motors, motor controllers, etc., must be connected to the ground, at minimum through two paths.

### 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 (SES CDEGS software is preferred).
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 Manitoba Hydro and CEC requirements. Values of resistivity to ground must be carefully measured and recorded 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.

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 lightning 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 7500 V 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 (SES CDEGS is the preferred 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 QUALITY

## 15.1 General

1. All designs and installations shall include equipment specifically designed to control and remove all adverse power quality conditions that could damage or impair function of any of the electrical or electronic equipment, which will be in use in the facilities. Adverse power quality conditions to be addressed include but are not limited to:
   1.1 Voltage surges;
   1.2 Voltage sags;
   1.3 Voltage transients;
   1.4 Harmonics;
   1.5 Power factor;
   1.6 Radio frequency interference; and
   1.7 Manitoba Hydro Power Quality Standard PQM-2000.

## 15.2 Power Factor Correction

1. Unless otherwise specified, 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 600 V, with numerous motor loads and potential harmonics, connection of one or more automatic 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 shall be based upon Table 15-1.
9. 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 documented with reports provided and incorporated into O&M information. The design adopted shall ensure safe operation and protection of associated equipment.

## 15.3 Application Requirements and Configurations

1. The configuration of power factor correction is classified into three types:
   1.1 Load Power Factor Correct (See Section 15.3.2)
   1.2 Decentralized Bulk Power Factor Correction (See Section 15.3.3)
   1.3 Centralized Bulk Power Factor Correction (See Section 15.3.4)
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 Application Requirements**

| Application | Requirement | Typical Configuration | Notes |
| --- | --- | --- | --- |
| Land Drainage / Underpass Pumping Station | Based upon Economic Evaluation | Load Power Factor Correction | |
| Regional Water Pumping Station | Required | Load Power Factor Correction (MV)<br>Decentralized Bulk Power Factor Correction (600 V) | |
| Flood Pumping Station | Based upon Economic Evaluation | Load Power Factor Correction | Review the economic benefit considering occasional use. |
| Wastewater Lift Station | Based upon Economic Evaluation | Load Power Factor Correction | |
| Flood and Wastewater Lift Station (combined) | Based upon Economic Evaluation | Load Power Factor Correction | |
| Wastewater Treatment Facility | Required | Decentralized Bulk Power Factor Correction (preferred)<br>or<br>Centralized Bulk Power Factor Correction | |
| Water Treatment Plant | Required | Decentralized Bulk Power Factor Correction (preferred)<br>or<br>Centralized Bulk Power Factor Correction | |

3. Wastewater treatment plants shall be designed to have a power factor target of 0.95. The design shall ensure that the average power factor over the worst load day shall never be less than 0.92 lagging.

## 15.3.2 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 need 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.
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
     - a) Connection of power factor correction capacitors at the motor terminals is acceptable for full voltage started motors only.
     - b) Do not apply to motors started by soft starters or VFDs.
     - c) Do not apply to motors which are subject to plugging, jogging, high-inertia, reversing, or open transient compound starting.
     - d) Maximum capacitor size as per motor nameplate or such that capacitor current <= motor no-load current.
     - e) 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
     - a) 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
     - a) Connection of power factor correction capacitors in this manner is acceptable for full voltage started motors only.
     - b) Do not apply to motors started by soft starters or VFDs.
     - c) Do not apply to motors which are subject to plugging, jogging, high-inertia, reversing, or open transient compound starting.
     - d) Maximum capacitor size as per motor nameplate or such that capacitor current <= motor no-load current.
   - 4.4 Connection Type B2 – Overload Cancelled
     - a) 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
     - a) Connection of power factor correction capacitors in this manner is acceptable for most motors.
     - b) Do not apply to motors started by VFDs.
     - c) 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.

d) 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.
6. For smaller facilities, such as wastewater lift stations and flood stations, where harmonics are present install detuning reactors on individual capacitors.

### 15.3.3 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. Provide 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.
5. All components in each automatic power factor correction cabinet will be designed to accommodate an additional 20% of the initial kVAR capacity in the future.

### 15.3.4 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 shall 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. Provide detuned power factor correction banks to prevent providing a low impedance path for harmonic currents that are present or may arise in the future. Detuned power factor correction banks shall be considered as standard and justification, with approval of the City, shall be required for elimination of this requirement.
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.

## 15.4 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.
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. Decay time shall be marked as a warning label on a cover protecting the terminals.
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 19.2.4.
2. Prepare fire alarm riser diagrams in accordance with Section 19.2.5.

## 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. Utilize IP based telephony for all large facilities, including wastewater treatment 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.

### 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 4-9.

## 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 process control system rather than a commercial-style security system. Video systems will be treated independently of the security systems connected to the process 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.
4. For NEWWPCC, please refer to WSTP NEWPCC Access Control Guideline

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# 17 PACKAGED SYSTEMS

## 17.1 General Requirements

Various process and mechanical equipment may be appropriate for packaging, where the equipment vendor provides a complete package, including electrical and automation equipment. For automation system packaging requirements, please refer to the Automation Design Guideline.

1. Vendor packaging of electrical equipment with the process equipment is permitted where:
   - 1.1 The equipment operation is complex or the technology is proprietary. Vendors of these packaging systems must be able to provide a complete proven system that can be fully tested at the factory. The vendors of these systems must provide assistance with the integration of the City's PCS system and the vendors control system, such that from the City Control Room the operator has visibility and control of the vendors packaged equipment.
   - 1.2 Where vendors are providing packaged equipment, should try and utilize City standardized equipment.
2. Vendor packaging of general building HVAC systems is permitted where:
   - 2.1 The packaged unit is dedicated to a non-process area such as a laboratory or Administration Building
   - 2.2 Vendor does not have to adhere to City standardized equipment
   - 2.3 Vendor must provide a suitable communication between the packaged unit and the PCS system to allow City Operations to monitor the unit's performance, adjust temperature and humidity set points, start/stop the unit, reset the unit on a fault and provide detailed alarms to the PCS on unit failure.
3. This section is still under development

**Table 17-1 : Wastewater Treatment Equipment Vendor Packaging**

| **Equipment** | **Permitted Packaging Type** | | | | **Comments** |
|---|---|---|---|---|---|
| | **1** | **2** | **3** | **NP** | |
| Air Handling Unit - General | Y | Y | Y | | Application dependant |
| Air Handling Unit with Fan Wall | | Y | Y | | Application dependant |
| Air Handling Unit – NG Fired | - | Y | Y | | Application dependant |
| Blowers - Turbo | Y | Y | Y | - | Application dependant |
| Blowers – conventional | | | | | |
| Clarifier Mechanism - Rotary | - | Y | Y | | |
| Compressor, Air, <= 3.7 kW | Y | Y | Y | | |
| Compressor, Air, > 3.7 kW | - | Y | Y | | |
| Compressor, Digester Gas | - | - | Y | | |
| Grit Classifier | - | - | | | |
| Fan - General | - | - | - | | |
| Mixers, Tank | - | - | - | | |
| Pump – Chemical Feed Pump | | | | | |
| Pump - General | | | | | |
| Rotary Drum Thickener | | Y | | | |
| Screens – Perforated Plate | | | | | |
| UV System | Y | | | | |
| | | | | | |
| **Legend** | | | | | |
| Packaging Type 1 | | Black Box | | | |
| Packaging Type 2 | | Standards except standardized equipment vendors | | | |
| Packaging Type 3 | | All standards including standardized equipment vendors | | | |
| Packaging Type NP | | Not Permitted | | | |

Note:

1. Packaging of equipment may be in accordance with Table 17-2 where the equipment is part of a system.

**Table 17-2 : Wastewater Treatment System Vendor Packaging**

| Equipment | Permitted Packaging Type | | | | Comments |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | NP | |
| Biofilter / Odour control system | - | - | Y | | |
| High Rate Clarifier - Actiflo® | - | - | Y | | |
| Polymer Mixing System | - | - | - | | TBD |
| Thermal Hydrolysis Process - Cambi® | - | - | - | | TBD |
| | | | | | |
| **Legend** | | | | | |
| Packaging Type 1 | | Black Box | | | |
| Packaging Type 2 | | Standards except standardized equipment vendors | | | |
| Packaging Type 3 | | All standards including standardized equipment vendors | | | |
| Packaging Type NP | | Not Permitted | | | |

# 18 ELECTRICAL ROOMS

## 18.1 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 a minimum of 150mm above outdoor grade level.
3. Where electrical rooms are subject to potential flood risk from a nearby process upset, locate the electrical room a minimum of 100 to 150 mm above the process floor level, or higher as required, to prevent a process flood incident from flowing into the electrical room.
4. Locate electrical rooms to allow for access of cables and conduits from all sides.
5. No process piping shall run through the electrical room.
6. No washroom or kitchen facilities shall be allowed directly above an electrical room.
7. 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.
8. Evaporating coils for air handling units will be located and arranged to prevent condensation from running onto electrical equipment in the event of a plugged drain.

9. Housekeeping pads:

   9.1 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.

      a) Housekeeping pads may be omitted where not compatible with certain types of draw-out switchgear.

   9.2 Size housekeeping pads to extend 50mm past the equipment.

   9.3 Housekeeping pads to be between 110 and 152 mm high.

   9.4 Provide rebar as structurally required.

## 18.2 Space and Location Requirements

1. Design new electrical rooms to provide a minimum of 25% usable floor space not allocated to installed equipment, O & M information, tools, spare parts, related safety equipment at the end of the project. In addition, a minimum of 10% of usable wall space shall be spare after all associated electrical single line drawings (D sized) are mounted on the walls. This space provision shall not be utilized for equipment that only becomes defined as the project progresses.

*Note: A common issue is that not all the electrical and automation equipment are known at the time of electrical room sizing. Electrical room sizing at the preliminary design stage may need to be 150 – 200% of the size required for the equipment known at this stage. Consider undefined requirements at the time of electrical room sizing.*

2. Design new electrical rooms to be sufficiently close to loads to prevent excessive feeder lengths. This may require the provision of multiple or additional electrical rooms.

   2.1 Ensure VFD motor lead length limits in this document and manufacturer's recommendations are adhered to.

## 18.3 Redundancy Requirements

1. Where electrical distribution redundancy is required, separate each bank of the electrical distribution, with a minimum of a 2-hour rated fire separation for:

   1.1 All medium voltage distribution systems with a bus rating of 10 MVA or greater.

## 18.4 Ventilation Requirements

1. Design ventilation and mechanical cooling as required to keep electrical rooms cool. Minimum requirements are as per the Mechanical Design Guide.

**Table 18-1 : Electrical Room Temperature Requirements**

| Type | Heating | | Cooling | |
|---|---|---|---|---|
| | Occupied | Unoccupied | Occupied | Unoccupied |
| Standard | 18°C | 10°C | 26°C | 26°C |
| Small & Non-Critical | 18°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.
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. Ensure that electrical rooms maintain a G1 – Mild classification as per ISA 71.04. 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.

# 19 ENGINEERING DESIGN TEAM RESPONSIBILITIES

## 19.1 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 registered in the Province of Manitoba.
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.
      a) Single line drawings must always be updated, such that a complete set of single line diagrams is provided for the facility.
      b) Panel schedule drawings must always be updated, such that a complete set of panel schedules is provided for the facility.
      c) Update of existing motor starter schematics and loop diagrams is required, wherever changes are being made to the content of the specific drawings.
      d) The update of existing electrical plan drawings to reflect new work is not typical, and is not required unless specifically identified by the City.
      e) 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, 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:
      a) Analysis and design of grounding system.
      b) Design of project specific specialized systems and equipment.
      c) Medium-voltage protection systems.
      d) Fire detection, protection and alarm systems.
      e) Corrosion protection systems.
      f) Area classification.

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.

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 project 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.

## 19.2 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.

### 19.2.1 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:

a) Recommended: 1:30 or 1:50

b) Maximum: 1:75

## 19.2.2 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:

a) Recommended: 1:30

b) Maximum: 1:50

## 19.2.3 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.

2.6 Show all Public Address (PA) system components.

3. Format:

3.1 All equipment plan layout drawings are to be produced on a standard A1 size drawing.

3.2 Drawing Scale:

a) Recommended: 1:50

b) Maximum: 1:100

## 19.2.4 Fire Alarm and Security Plan

1. Requirement

   1.1 Fire Alarm and Security Plan Drawings are required for all facilities with a fire alarm and/or security system.

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 fire alarm 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 all security access control systems.

   2.6 Show the routing of major conduits on the plan drawing.

   2.7 Show all isolators.

3. Format:

   3.1 All fire alarm and security drawings are to be prepared on a standard A1 size drawing.

   3.2 Drawing Scale:

      a) Recommended: 1:50 – 1:100

      b) Maximum: 1:150

## 19.2.5 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.

### 19.2.6 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.
   2.3 Clearly show the location of all ground electrodes.
   2.4 Clearly show conductor material type and size requirements.
   2.5
3. Format:
   3.1 All grounding diagrams are to be produced on a standard A1 size drawing.
   3.2 Drawing Scale - Interior:
      a) Recommended: 1:50
      b) Maximum: 1:100
   3.3 Drawing Scale - Exterior:
      a) Recommended: 1:50 - 1:100
      b) Maximum: 1:150
   3.4 Provide details and sections at a lower scale as required to clarify grounding requirements.

### 19.2.7 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:
      a) Recommended: 1:50
      b) Maximum: 1:100

3.3 Provide details and sections at a lower scale as required to clarify hazardous locations around equipment.

### 19.2.8 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 Include all exit lighting.
   2.3 Indicate circuit numbers beside each fixture.
   2.4 Indicate all lighting control.
   2.5 All lighting plan drawings shall reference a luminaire schedule. Where an existing luminaire schedule exists for a building or building area being modified, 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:
      a) Recommended: 1:50
      b) Maximum: 1:100
   3.3 Drawing Scale: - Exterior Drawings:
      a) Maximum: 1:100

### 19.2.9 Lightning Protection Drawings

1. Requirement:
   1.1 Lightning Protection Drawings are to be prepared for every project with lightning protection.
   1.2 Lighting protection drawings may be integrated into the overall grounding diagrams, but shall not be combined with other general rood arrangement drawings unless specifically approved by the City.
2. Content:
   2.1 Air terminals height and locations;
   2.2 Arrangement of main and down conductors;
   2.3 Grounding points and spacing;
   2.4 Bonding of roof drawings
   2.5 Sizing of conductors;
   2.6 Protection of conductors;
   2.7 Testing requirements of grounds; and
   2.8 Standard details.

3. Format:
   3.1 All lightning plan drawings are to be produced on a standard A1 size drawing.
   3.2 Drawing Scale (other than standard details):
      a) Recommended: 1:50
      b) Maximum: 1:100

## 19.2.10 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:
      a) Equipment Identifier
      b) Enclosure Type
      c) Mounting
      d) Depth
      e) Supply voltage, phase, frequency
      f) Incoming neutral termination
      g) Control voltage
      h) Wiring Class
      i) Minimum bus rating (amps) for horizontal and vertical bus.
      j) Suitable for service entrance
      k) Neutral Bus
      l) Bus Bracing
      m) SCCR
      n) Series SCCR Permitted
      o) Bus Material
      p) 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:
      a) Recommended: 1:10

### 19.2.11 MCC Schedule

1. Requirement:
    1.1 A MCC Schedule is required for every MCC.
2. Content:
    2.1 Identify in tabular format:
        b) MCC Identifier
        c) Description
        d) Location
        e) Volts
        f) Amp Rating
        g) Phases
        h) Wires
        i) Main Breaker
            i. Rating
            ii. Type
            iii. Settings
        j) Total Connected Load
        k) Total Demand Load
        l) Legend
    2.2 For each unit within the MCC, provide a row within the table with the following clearly identified:
        a) Unit Location
        b) Load Identifier
        c) Load Description
        d) Motor Load (kW/hp/FLA)
        e) Non-Motor Load (kW)
        f) Starter
            i. NEMA Size
            ii. Type
            iii. Overload
        g) Circuit Protection
            i. Rating
            ii. Type
        h) Notes
3. Format:
    3.1 All MCC Schedules are to be produced on a standard A1 size drawing.

## 19.2.12 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.

## 19.2.13 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 600 V motors, with minor to medium complexity, it is typical that the motor connection diagram is integrated with the schematic on the same drawing.

## 19.2.14 PA Riser Diagram

1. Requirement
   1.1 Public Address (PA) Riser Diagrams are required for all facilities with a PA system.
2. Content
   2.1 Provide a riser diagram that shows the complete details (not typical) for all PA system components.
   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 amplifiers and connections to telecom / network systems.
3. Format:
   3.1 All PA Riser Diagrams are to be prepared on a standard A1 size drawing.

## 19.2.15 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:

   a) Panel identifier
   b) Amp rating, volts, phases, wires
   c) Surface / flush mount
   d) Top / bottom feed
   e) Description
   f) Location
   g) Manufacturer / Model
   h) Interrupting Rating
   i) Main Breaker
   j) Main Breaker Settings

   2.2 Show for each circuit:

   a) Circuit number
   b) Load description
   c) Notes
   d) Wire size
   e) Breaker rating
   f) Load (VA)
   g) 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.

## 19.2.16 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, 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.
   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.

## 19.2.17 Security Riser Diagram

1. Requirement
   1.1 Security Riser Diagrams are required for all facilities with a security and/or access control system.
2. Content
   2.1 Provide a riser diagram for both the detection system and the notification system.
   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.
3. Format:
   3.1 All security riser diagrams are to be prepared on a standard A1 size drawing.

## 19.2.18 Single Line Diagrams

1. Requirement:
   1.1 Single Line Diagrams are critical and shall be prepared for every facility.
   1.2 Single line diagrams shall be fully detailed and indicate the full electrical distribution from the source to the load.

2. Content

2.1 Each piece of equipment shall have the equipment identifier shown, as well as major equipment ratings.

a) Equipment ratings to include, but not be limited to voltage and ampere ratings

b) Show short circuit current ratings.

2.2 All medium voltage, 600 V, and 480 V loads shall be shown in detail on the single line diagrams.

a) Underneath each load indicate, in order from top to bottom, Equipment Identifier, description, load ratings

b) Indicate Full Load Amps for motor loads.

i. Utilize reasonable assumed full load currents until actual motor full load amps are known.

c) Update all load ratings (including full load amps) on the as-built drawings.

2.3 Show all mechanical, Kirk key and electrical interlocks.

2.4 Show connected and demand loads at each distribution point.

2.5 Show service and transformer grounding including details and protections associated with neutral grounding resistors.

2.6 Each cable shall have an identifier and cable size/type shown.

2.7 Show calculated arc flash incident energies at all points in the electrical distribution.

2.8 Show all electrical equipment interface connections to a PLC or any other equipment within the Process Control System.

2.9 Any notes or reference drawing information shall be noted on the drawing.

2.10

3. Format:

3.1 All single line drawings are to be produced on a standard A1 size drawing. If a facility cannot 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. For MCC single line drawings, group loads from the same vertical section of a MCC.

3.4 Partial single line diagrams for renovations are not acceptable.

3.5 All text shall be 2.5mm high unless otherwise specified.

3.6 Arc flash incident energies shall be shown in an octagon, with two lines of text:

3.6.1 The first line: “I.E.” representing incident energy (2.0 mm high text); and

3.6.2 The second line “12.3” where 12.3 is the calculated incident energy in $cal/cm^2$ in 2.5 mm high text.

3.7 Show all electrical equipment interface connections to the PCS as a dashed line to a diamond, 10 mm wide by 10 mm high, with “PCS” in the diamond. The dashed line may represent multiple signals. The text may be 2.0 mm or 2.5 mm high as appropriate.

### 19.2.19 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.

## 19.3 Other Documents

### 19.3.1 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, 1000 V)
      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
   2.4 The length for each cable shall be estimated at design time to within ~10% accuracy for purposes of pre-bid cost estimating and electrical system modelling.
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.

### 19.3.2 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:

      a) Lamacoids for cables may reference the cable schedule.

   2.2 The lamacoid schedule shall at minimum include the following fields:

      a) Item
      b) Line 1
      c) Line 2
      d) Line 3
      e) Text Size
      f) Notes

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.

### 19.3.3 Protection Settings Datasheets

1. Requirement:

   1.1 Protection Settings Datasheets are required for all projects with service equipment rated >= 1000 kVA. For projects with lower capacity, protection settings shall be shown on the drawings.

   1.2 Provide a protection settings datasheets for all equipment with configurable electrical protection settings, including but not limited to:

      a) Breakers with L, LI, LSI, and LSIG settings;
      b) Protection Relays;
      c) Variable Frequency Drives;
      d) Soft Starters; and
      e) Intelligent Motor Starters.

2. Content:

   2.1 Indicate all applicable settings for the device along with the setting.

   2.2 The datasheets schedule shall at minimum include the following fields:

      a) Device name and location
      b) Setting name;
      c) Setting value; and
      d) A revision code next to each setting so that it is clear which revision of a document changed a setting.

3. Format:

    3.1 Provide datasheets in editable Microsoft Word format, with settings in form format.

## 19.4 Design Calculations and Studies

### 19.4.1 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 19-1.
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.
5. The calculations and studies shall only be deferred to the Contractor after review and agreement with the City.

### 19.4.2 Voltage Stability Study

1. Without limiting the general requirements to meet voltage drop requirements for all facilities with a service size greater than 1 MVA perform a voltage stability study to ensure that under all facility and utility operating scenarios that the power supply to the facility remains acceptable, avoiding any impact to operations or degrading the service life of the equipment.

### 19.4.3 Short Circuit, Coordination and Arc Flash Study

1. For all facilities, provide a comprehensive study and report which includes:
   - 1.1 Short circuit analysis including protective device evaluation
   - 1.2 Protective device coordination study
   - 1.3 Arc flash analysis
2. The Short Circuit, Coordination and Arc Flash Study shall be iteratively performed as part of the design process to ensure that the design is optimal, including short circuit, selective coordination and arc flash considerations.
3. Provide comprehensive arc flash labelling of all equipment:
   - 3.1 Type and style of label shall be submitted to and approved by the City prior to generating final labels.
   - 3.2 Detailed electrical hazard warning shall be compliant with part Q.4 of Annex Q of standard Z462-15 and produced and installed per ANSI Z535.4.
4. Refer to Appendix A – Arc Flash Study and Electrical System Modeling Requirements for detailed requirements.

### 19.4.4 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.

### 19.4.5 Instrument Transformer Sizing Calculations

1. Provide instrument transformer sizing calculations to justify selection of current and potential transformer ratings, including ratios, accuracy, and burdens, etc.
2. Current transformer calculations shall be based on IEEE C 37.110 “Guide for the application of Current Transformers Used for Protective Relaying Purposes” and take into account expected loading, short circuit levels, X/R values, protective relaying burdines, etc.

**Table 19-1 : 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 Heating and Cooling 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.<br>See Section 19.4.2 |
| 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. |

## 19.5 Example - Typical Deliverables for a Lift Station

Typical electrical deliverables for a wastewater lift station are shown in Table 19-2.

**Table 19-2 : 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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# 20 SAMPLE DRAWINGS

| | |
|---|---|
| SK-101 | Single Line Diagram, MCC-M710 |
| SK-102 | Single Line Diagram, 4160 V 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 |

# Appendix A

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# APPENDIX A

# ARC FLASH HAZARD STUDY AND ELECTRICAL SYSTEM MODELING REQUIREMENTS

## 1. DEFINITIONS

1.1.1 In this document, in addition to the definitions set out in the Electrical Design Guide, the following expressions have the following meanings (and, where applicable, their plurals have corresponding meanings):

(a) Arc Flash Hazard – a source of possible injury or damage to health associated with the release of energy caused by an electric arc.

(b) “Arc Flash Labels” has the meaning indicated in Annex Q of CSA Standard Z462 current edition.

(c) “Arc Flash, Short Circuit and Coordination Study Report” means the report indicated in Section xx.

(d) “HRC” means Hazard Risk Category as used in relation to Arc Flash Hazards.

(e) “MCC” means Motor Control Centre.

(f) “TCC” has the meaning time-current characteristic curves.

(g) “SKM Power*Tools for Windows” (SKM) has the meaning indicated in Section xx.

(h) “Work” or “Works” means the carrying out and the doing of all things, whether of a temporary or permanent nature, that are to be done by the contractor pursuant to this contract and, without limiting the generality of the foregoing, includes the furnishing of all plant, material, labour and services necessary for or incidental to the fulfilment of the requirements of this contract, including all Changes in Work.

## 2. ARC FLASH STUDY AND ELECTRICAL SYSTEM MODEL

### 2.1 Arc Flash Hazard Study and Associated Work

2.1.1 The consultant will complete the Arc Flash Hazard Study and all associated work outlined below using an SKM model and turn over the model and associated libraries to the City for its use at the end of the Work.

2.1.2 The systems shall be designed with Arc Flash restrictions as a consideration and, where possible with new systems, the Arc Flash restrictions shall be maintained at a Hazard Risk Category (HRC) of two (2) or lower as defined within CSA Z462.

2.1.3 The consultant shall ensure that all calculations, analyses, and recommendations for the Work meet the requirements of the latest edition of the following industry standards.

| | |
|---|---|
| CSA C22.1 | Canadian Electrical Code, Part I – Safety Standard for Electrical Installations (CEC) |
| CSA Z462 | Workplace electrical safety (Z462) |

| | |
|---|---|
| IEEE 1584 | IEEE Guide for Performing Arc–Flash Hazard Calculations (IEEE 1584) |
| IEEE 141 | IEEE Recommended Practice for Electric Power Distribution for Industrial Plants (IEEE 141, or the Red Book) |
| IEEE 241 | IEEE Recommended Practice for Electric Power Systems in Commercial Buildings (IEEE 241, or the Grey Book) |
| IEEE 242 | IEEE Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems (IEEE 242, or the Buff Book) |
| IEEE 399 | IEEE Recommended Practice for Industrial and Commercial Power System Analysis (IEEE 339, or the Brown Book) |
| IEEE 551 | Recommended Practice for Calculating AC Short–Circuit Currents in Industrial & Commercial Power Systems (IEEE 551, or the Violet Book) |
| IEEE 1015 | IEEE Recommended Practice For Applying Low Voltage Circuit Breakers Used in Industrial and Commercial Power Systems (IEEE 1015, or the Blue Book) |
| ANSI / IEEE C37.010 | IEEE Application Guide for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis (IEEE C37.10) |
| ANSI / IEEE C37.13 | IEEE Standard for Low-Voltage AC Power Circuit Breakers Used in Enclosures (IEEE C37.13) |
| | The Manitoba Electrical Code and the Winnipeg Electrical By-law |

## 2.2 Scope of Study

2.2.1 The scope of the study shall be based on the Works including the complete facility in its existing condition, and all transitional stages up to the final configuration.

2.2.2 The City will supply to the consultant:

(a) the anticipated Services required, if they deviate from those outlined in this section;

(b) any available single line diagrams showing the modes of operation and the configurations to be studied;

(c) any existing arc flash models for the facility. The existing model is supplied as is and the consultant shall validate and update the model with the Works as required;

(d) Manitoba Hydro supplied utility information regarding fault levels and supply transformer(s);

(e) other available information as required by the consultant for completion of the analysis; and

(f) site access for data collection and verification.

2.2.3 The consultant shall be responsible for removing existing Arc Flash Labels.

2.2.4 The consultant shall provide and install Arc Flash Labels for the entire facility in a manner such that equipment is always labelled with current arc flash values.

## 2.3 Design Requirements

2.3.1 All new and modified electrical designs shall ensure that arc flash energies are within the ratings specified in Table 2.3-1.

2.3.2 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 2.3-1 : Arc Flash Design Requirements**

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

## 2.4 General Requirements

2.4.1 As part of any Arc Flash Hazard Study assignment, the consultant shall include:

(a) a short circuit analysis with protective device evaluation;

(b) a protective device coordination study; and

(c) a single-line diagram of the system showing results of the analysis. The single line diagram will done following current City drafting standards on current City drawing title blocks and will be signed by the engineer referenced in Item.

(d) Upon completion, the consultant shall submit a draft and final report detailing the findings.

2.4.2 The consultant shall conduct the Arc Flash Hazard Study under the supervision and approval of an EGM registered professional electrical engineer with a minimum of five (5) years' experience in performing and interpreting power system studies including Arc Flash Hazard.

2.4.3 The consultant shall utilize the most current version of the SKM Power*Tools for Windows software package to perform all modelling and analysis.

2.4.4 Where the City has existing studies in its records using SKM software, the consultant shall incorporate and consolidate these SKM models into its model. The consultant shall be responsible for verification of any existing models provided by the City. The consultant may rely on the existing models for the purpose of arc flash modelling, however, no reliance on the models may be utilized for any other purpose associated with the design

2.4.5 The consultant shall coordinate with the City to acquire details required to complete the analysis. The consultant shall perform a document review of available documents and drawings prior to formally verifying all documentation on site.

2.4.6 The consultant shall arrange, with the Contract Administrator, travel to each site to acquire the necessary data required to complete the study.

2.4.7 The Consultant shall be made aware of and shall follow all site safety requirements.

2.4.8 Data collection, verification and analysis shall begin at the Utility point of service and include all downstream AC electrical equipment, including but not limited to:

(a) Switchgear, distribution switchboards, panelboards and MCCs rated 120/208 volts and higher. (This criterion is more stringent than the Standards covering Arc Flash Hazard Study and shall be used by the consultant to define the Scope of Study;

(b) disconnect switches;

(c) neutral grounding resistors;

(d) standby generators;

(e) manual transfer switches;

(f) automatic transfer switches;

(g) busway and splitters;

(h) motor starters;

(i) power factor correction equipment;

(j) adjustable speed drives;

(k) all medium voltage equipment;

(l) primary and secondary transformer connection cubicles; and

(m) other significant locations throughout the system as identified by the City.

2.4.9 The consultant shall also carry out the analysis of any DC equipment using DC incident energy calculations found in CSA Z462 Annex D Section D.5.

2.4.10 For existing distributions, the consultant shall verify all equipment nameplates and ratings; protective device manufacturers, types, sizes and settings; cable sizes, types, lengths, raceways and configurations; and other relevant details on–site to confirm the accuracy of the City's drawings and previous Arc Flash Hazard Study studies.

2.4.11 Transformer design impedances shall be used when actual test impedances are not available. The consultant shall consider the full range of impedances for transformers equipped with on-load tap changers to determine the worst case scenario.

2.4.12 Motor contributions shall be incorporated in determining fault levels as follows:

(a) all Medium voltage motors shall be individually modelled;

(b) all 600V motors equal to or greater than 50 HP shall be individually modelled; and

(c) all smaller motors shall be lumped into groups, with each grouping not to exceed 50HP, feeding their nearest panelboard, MCC or distribution switchgear.

2.4.13 The consultant shall use actual conductor impedances and configurations if known. If actual values are not known, typical impedance values shall be obtained from manufacturer for the given configuration or calculated from the given materials, geometry and configuration used.

2.4.14 Any information from manufacturers and any calculated or assumed values shall be supplied, in an appendix with clear reference to report sections, as information in the final report.

### 2.5 Short Circuit Analysis with Protective Device Evaluation

2.5.1 The consultant shall perform a short circuit analysis with a protective device evaluation based on this section and the General Requirements section.

2.5.2 Four operating scenarios are to be evaluated:

(a) Scenario 1 will represent an “Infinite Bus” scenario per Winnipeg Electrical By-law (By-law No. 86/2018) Rule 14-012:

(i) The calculation will assume an infinite primary bus.

(ii) The percent impedance for transformers will be the percent impedance of the installed transformer or the value provided by Manitoba Hydro for a utility-owned transformer.

(b) Scenario 2 and Scenario 3 will be based on the Manitoba Hydro provided normal and expected maximum available fault levels at the point of utility interconnection.

(c) Scenario 4 will represent a very low short-circuit current that can be reached at the point of interconnection.

2.5.3 Calculations shall be performed to represent the maximum and minimum contributions of fault current magnitude for all normal and emergency operating conditions. The minimum calculation will assume that the system contribution is at a minimum with minimum motor contribution (all motors off). Conversely, the maximum calculation will assume a maximum contribution from the system and will assume the maximum amount of motors is operating.

2.5.4 Calculations shall be based upon all configuration scenarios including extreme supply conditions from the utility.

2.5.5 The analysis calculation methodology shall be in accordance with the listed IEEE and ANSI C37 standards. Short circuit calculations shall be prepared in SKM Systems Analysis software.

2.5.6 Calculate the short circuit momentary and interrupting duties for a three-phase bolted fault and single-line-to-ground faults at each location in Item 2.3.7. Include any planned future standby generation.

2.5.7 Evaluate all electrical equipment’s short circuit withstand rating within the Works at calculated short circuit levels.

2.5.8 Evaluate all protective devices’ interrupting capacities at the calculated short circuit level of their associated switchboard, MCC or panelboard, etc.

2.5.9 Results of the equipment and protective device evaluation shall be presented in tabulated form within the short circuit evaluation analysis comparing the highest calculated fault level to the device withstand/interrupting ratings.

2.5.10 Include the following information in the tabulation:

(a) Bus identifier.

(b) Device name.

(c) Manufacturer and description of equipment.

(d) Voltage.

(e) Device withstand or interrupting rating.

(f) Suitability of device interrupting rating.

(g) Calculated short circuit current for each Scenario identified in Item 2.4.2.

(h) Example table:

| Bus ID | Device Name | Manufacturer/ Description | Voltage | Device Rating | Suitability | Calculated Current | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Scenario 1 | Scenario 2 | Scenario 3 | Scenario 4 |
| | | | | | | | | | |

2.5.11 For the equipment within the facility, the consultant shall notify the City, in writing, of circuit protective devices and any system component inadequately rated for the calculated available fault current.

2.5.12 Inadequate rating of any equipment supplied or modified under the Work is not acceptable.

## 2.6 Protective Device Coordination Study

2.6.1 The consultant shall perform a protective device coordination study based on the requirements outlined in this section and in the General Requirements section.

2.6.2 The consultant shall verify any built-in SKM device models used in the software model against device manufacturer's documentation. Any device that is not present within the SKM library shall be modelled as a custom device as per the manufacturers most current product information for the specific device installed.

2.6.3 The consultant shall prepare and present time-current characteristic curves (TCC), displayed on log-log scale graphs. All curve sheets shall be multi-colored for improved clarity. Include on each TCC graph:

(a) a complete title and one-line diagram with legend identifying the specific portion of the system covered and the configuration used;

(b) voltage at which curves are plotted;

(c) current multiplier; and

(d) ANSI frequent fault damage curves.

2.6.4 The equipment modeled shall include:

(a) fuses including manufacturer's minimum melt, total clearing, tolerance, and damage bands;

(b) low voltage circuit breaker trip devices, including manufacturer's tolerance bands;

(c) transformer full-load current, magnetizing in-rush current, and ANSI through-fault protection curves for both bolted and single line to ground fault conditions;

(d) conductor damage curves;

(e) pertinent motor starting characteristics and motor damage points where applicable;

(f) the largest feeder circuit breaker in each MCC and applicable panelboards; and

(g) ground fault protective devices, as applicable. To increase clarity of TCCs multiple ground fault devices in a circuit shall be shown on a separate TCC.

2.6.5 The TCC shall be used to determine the required sizes and settings of the protective devices to optimize selectivity and meet Canadian Electrical Code requirements.

(a) Provide adequate time margins between device characteristic curves such that selective operation is provided, while providing proper protection.

(b) For each device, show the as-found settings. Identify the device associated with each curve by device name, manufacturer, device type, function, and, if applicable, tap, time delay, and pick-up settings.

(c) Terminate device characteristic curves at a point reflecting maximum symmetrical or asymmetrical fault current to which the device is exposed.

(d) Where applicable, the incoming Manitoba Hydro protective devices shall be the most upstream device analyzed in a coordination study. The consultant shall coordinate Manitoba Hydro protection TCC with the rest of the system. If necessary, a Manitoba Hydro contact will be provided to the consultant by the City.

(e) Where devices are existing, changes to settings are to be shown on a separate TCC with associated devices demonstrating the improved coordination. The revised setting shall be recommended to the City and presented in the report as final only when the City has agreed to allow the changes. Where changes are required, they shall be clearly identified in a separate table with their corresponding device names to ensure that changes are made as the labels are applied. The consultant shall implement the proposed changes.

2.6.6 A narrative analysis shall accompany each coordination curve sheet and describe the coordination and protection in explicit detail. Areas lacking complete coordination shall be highlighted, and the consultant shall provide reasons for allowing the condition to remain as-is or provide recommendations to resolve the situation.

2.6.7 The consultant shall provide all final protective device settings in a table, including all enabled elements (overcurrent, ground overcurrent, differential, restricted earth, etc.), as well as supporting calculations justifying selected settings.

## 2.7 Arc Flash Hazard Study

2.7.1 The consultant shall perform an Arc Flash Hazard Study based on the guidelines outlined in this section and in the General Requirements section.

2.7.2 The flash protection boundary and the incident energy shall be calculated at all significant locations in the electrical distribution system as outlined in CSA Z462 and Annex D - IEEE 1584 calculation method where work could be performed on energized parts.

(a) Separate calculations shall be made for different compartments within the same overall equipment where the arc flash energies will be different.

(i) For example, the main incoming breaker compartments and feeder breaker compartments in medium voltage switchgear shall have independent arc flash calculations performed.

(b) For each equipment location with a separately enclosed main device (where there is adequate separation between the line side terminals of the main protective device and the work location), calculations for incident energy and flash protection boundary shall be provided for both the line and load side of the main breaker.

(i) When performing incident energy calculations on the line side of a main breaker the line side and load side contributions shall be included in the fault calculation.

(c) The calculations at tie-breakers or other locations where two sources may contribute to an arcing fault at a common piece of equipment or switchgear cell, the arc flash energy shall be calculated based on combined contributions from both sources, regardless of the normal operating state of the device.

(d) Safe working distances shall be based upon the calculated arc flash boundary as per CSA Z462. Safe working distances shall be determined for both the circumstance of the conductors exposed and the circumstance of covers closed and fully latched and bolted.

(e) Arc flash calculations shall be based on actual overcurrent protective device clearing time. Maximum clearing time will be capped at two (2) seconds based on IEEE 1584 section B.1.2: Where it is not physically possible to move outside of the arc flash protection boundary in less than two (2) seconds during an arc flash event, a maximum clearing time based on the specific location shall be utilized.

(f) Arc Flash Hazard results table summary, which shall include:

(i) Location & equipment designation;

(ii) Nominal voltage;

(iii) Flash protection boundary;

(iv) Incident energy; and

(v) Working distance.

2.7.3 The short circuit calculations and the clearing times of the phase overcurrent devices will be determined from the City's provided drawings and information, and equipment model numbers verified by the consultant.

(a) The short circuit calculations and the corresponding incident energy calculations for multiple system scenarios shall be compared, and the greatest incident energy shall be uniquely reported for each equipment location.

(b) The incident energy calculations shall consider the accumulation of energy over time when performing arc flash calculations on buses with multiple sources. Iterative calculations must take into account the changing current contributions, as the sources are interrupted or decremented with time. Fault contribution from motors and generators should not be considered beyond 3-5 cycles.

2.7.4 Mis-coordination should be checked amongst all devices. The calculation shall utilize the fastest device to compute the incident energy for the corresponding location.

2.7.5 The consultant shall review existing protection settings/devices for proper coordination. The consultant shall recommend mitigation measures to reduce the arc flash hazard as appropriate. These recommendations may include but are not limited to either equipment protection and/or improving arc flash incident energy levels by adjusting existing protection settings/devices. The corresponding incident energy levels shall be provided where improvements can be made.

## 2.8 Final Report

2.8.1 All final reports and drawings shall be sealed by a Professional Electrical Engineer registered and in good standing with EGM.

2.8.2 The Arc Flash, Short Circuit and Coordination Study Report shall include the following sections:

(a) Executive summary.

(b) Descriptions, purpose, basis and scope of the study.

(c) Modes of operation studied.

(d) List of assumptions made where specific information was not available.

(e) List of all study input data, including but not limited to: Utility information; motor data; transformer data; cable sizes, types and lengths; protective device types and settings; etc.

(f) Short Circuit Study

(i) Tabulation of distribution equipment, circuit breaker, fuse and other protective device withstand and interrupting ratings versus calculated short circuit duties as per Items 2.4.9 and 2.4.10.

(ii) Results of short circuit study listing equipment that is applied above short circuit current rating and recommendations if appropriate.

(g) Protective Device Coordination Study

(i) TCC curves demonstrating protective coordination for all segments of the Work including all interfaces to the facility distribution.

(ii) Explanatory descriptions to any curves or graphs shall be provided to aid with interpretation.

(iii) Tabulation of all protective device settings and fuse selections.

(iv) Recommendations to improve coordination and/or reduce arc flash energies.

(v) Tabulation of all recommended settings.

(h) Arc Flash

(i) Fault current calculations including a definition of terms and a guide for interpretation of the results.

(ii) Details of the incident energy and flash protection boundary calculations for each scenario analyzed.

(iii) Design methodology employed to reduce arc flash energies and provide for selective coordination.

(i) Single-line diagram of the Work, which shall include:

(i) transformer rating, voltage ratio, impedance, and winding connection;

(ii) feeder cable phase, neutral and ground sizes, length of cable, conductor material, and conduit size and type where applicable;

(iii) switchgear, switchboards, panelboards, MCCs, fuses, circuit breakers and switches continuous ratings and interrupting capabilities or withstand capacities, as applicable;

(iv) protective relays with appropriate device numbers, CTs and PTs with associated ratios;

(v) detailed legend indicating device type identification and other significant details; and

(vi) incident arc flash energies.

2.8.3 The consultant shall provide the City with a copy of the final SKM Systems Analysis model generated for each stage of the Works. The final update will include all work performed to date by the consultant for each facility.

## 2.9 Final Deliverables

2.9.1 Prior to Total Performance, the consultant shall submit:

(a) electronic Word and pdf copies of the Arc Flash, Short Circuit and Coordination Study Report;

(b) three (3) bound, color, paper copies of the final Arc Flash, Short Circuit and Coordination Study Report, with drawings and TCCs formatted as 11x17 pages and folded into the report;

(c) native SKM Power Tools model and library files, including all scenarios assessed; and

(d) single line drawings shall be submitted as AutoCAD dwg files, pdf files and oversize ISO A1 drawings printed on Mylar.

## 2.10 Labelling

2.10.1 The consultant shall remove existing Arc Flash Labels prior to installing new labels.

2.10.2 Arc flash labels shall utilize metric units.

2.10.3 The consultant shall provide and install detailed Arc Flash Labels on all electrical equipment encompassed by the Arc Flash Hazard Study.

2.10.4 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.

2.10.5 The arc flash label format used for equipment rated Category 0 through Category 4 is shown in Figure 2.9-1 and Figure 2.9-2.

(a) Warning labels are to utilize an orange heading with the word “Warning”.

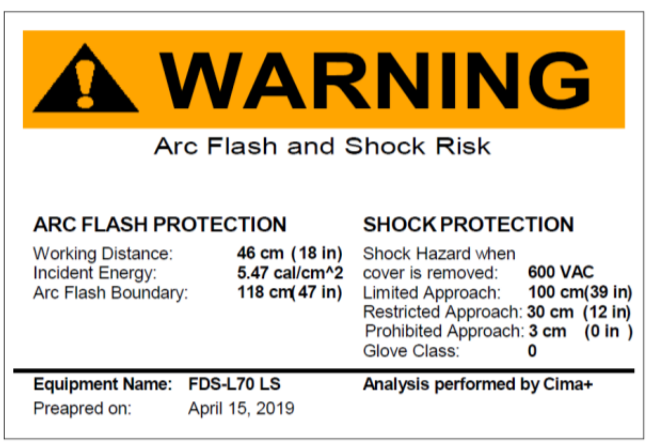


Figure 2.9-1

(b) For equipment that is given a Dangerous category rating, the arc flash labels are to utilize a red heading with the word “Danger”.

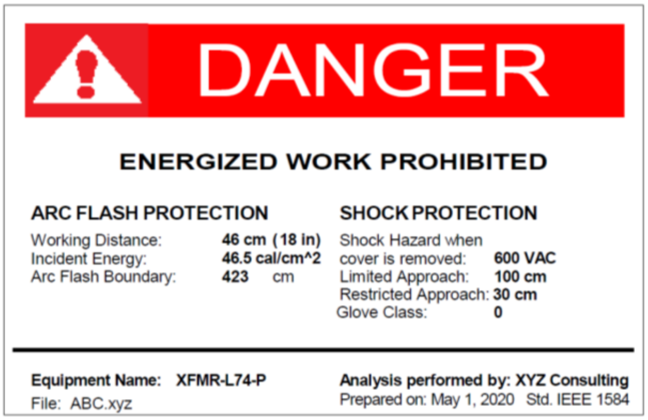


Figure 2.9-2

2.10.6 The consultant shall coordinate with the City to provide an Arc Flash Label format and size acceptable to the City. Type and style of label shall be submitted to the City and endorsed as “Reviewed” prior to final printing and application of labels.

2.10.7 Detailed electrical hazard warning shall be compliant with CSA Z462 Annex Q Section Q.4 and produced and installed per ANSI Z535.4. Labels shall be vinyl, waterproof with UV Resistance and a five (5) year rated life.