# Volume 5 Contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volume 5 Contents</td>
<td>i</td>
</tr>
<tr>
<td>1.0 Revision History</td>
<td>1</td>
</tr>
<tr>
<td>2.0 Introduction</td>
<td>2</td>
</tr>
<tr>
<td>3.0 Abbreviations</td>
<td>3</td>
</tr>
<tr>
<td>4.0 Overview</td>
<td>6</td>
</tr>
<tr>
<td>5.0 Process Control Description Requirements</td>
<td>6</td>
</tr>
<tr>
<td>5.1 Introduction</td>
<td>6</td>
</tr>
<tr>
<td>5.2 Design Coordination</td>
<td>7</td>
</tr>
<tr>
<td>5.3 Process Control Modes</td>
<td>8</td>
</tr>
<tr>
<td>5.4 Control Strategy Determination and Design</td>
<td>11</td>
</tr>
<tr>
<td>5.5 Process Control Description Content and Structure</td>
<td>11</td>
</tr>
<tr>
<td>5.6 Specific PCD Development Requirements</td>
<td>15</td>
</tr>
<tr>
<td>5.7 Example Process Control Description</td>
<td>21</td>
</tr>
<tr>
<td>6.0 Process and Instrumentation Diagrams (P&amp;IDs)</td>
<td>21</td>
</tr>
<tr>
<td>6.1 Introduction</td>
<td>21</td>
</tr>
<tr>
<td>6.2 Background</td>
<td>22</td>
</tr>
<tr>
<td>6.3 P&amp;ID Development</td>
<td>22</td>
</tr>
<tr>
<td>6.4 Interface with Process Control Descriptions</td>
<td>25</td>
</tr>
<tr>
<td>6.5 Use of P&amp;IDs during Final Design, Construction, Commissioning, and Testing</td>
<td>26</td>
</tr>
<tr>
<td>6.6 Standard Legend, Symbols, and Abbreviations Sheet</td>
<td>26</td>
</tr>
<tr>
<td>6.7 Sample Loop Diagram</td>
<td>34</td>
</tr>
<tr>
<td>6.8 Installation Details</td>
<td>35</td>
</tr>
<tr>
<td>6.9 Control Network Block Diagrams</td>
<td>38</td>
</tr>
<tr>
<td>6.10 Control Panel Layout</td>
<td>41</td>
</tr>
<tr>
<td>6.11 P&amp;ID Guideline/Mapping</td>
<td>51</td>
</tr>
<tr>
<td>6.12 Sample P&amp;IDs</td>
<td>52</td>
</tr>
<tr>
<td>7.0 Control Panel Design</td>
<td>53</td>
</tr>
<tr>
<td>7.1 Introduction</td>
<td>53</td>
</tr>
<tr>
<td>7.2 Control Panel Layout Requirements</td>
<td>54</td>
</tr>
<tr>
<td>7.3 Maximum Allowable Voltage</td>
<td>57</td>
</tr>
<tr>
<td>7.4 Control Panel Identification Nameplate Legend Convention</td>
<td>57</td>
</tr>
</tbody>
</table>
8.0 Patch Panel Design .......................................................................................................... 59
  8.1 Patch Panel Requirements ........................................................................................... 59
9.0 Network/Server Rack ....................................................................................................... 60
  9.1 Introduction .............................................................................................................. ..... 60
  9.2 Network/Server Rack Requirements ............................................................................ 60
10.0 Security ................................................................................................................. ........... 61
  10.1 Introduction ............................................................................................................. ...... 61
  10.2 Physical Security ........................................................................................................ .. 61
  10.3 Virtual Security ......................................................................................................... .... 63
  10.4 Access Policies.......................................................................................................... ... 64
11.0 Network Architecture ..................................................................................................... ... 64
12.0 Alarm Management ......................................................................................................... . 64
  12.1 Purpose and Use of the Alarm Management Policy ..................................................... 64
  12.2 Alarm Definition and Selection Criteria ................................................................. 66
  12.3 Alarm States and Transitions ....................................................................................... 67
  12.4 Alarm Annunciation and Response .............................................................................. 69
  12.5 Alarm System Performance Auditing ............................................................................ 71
  12.6 Alarm Handling Methods .............................................................................................. 76
  12.7 Alarm Documentation and Rationalization ............................................................... 79
  12.8 Specific Alarm Design Consideration ........................................................................... 84
  12.9 Management of Change ............................................................................................... 85
  12.10 Training ................................................................................................................ ..... 86
  12.11 Alarm Maintenance and Improvements Process .................................................... 86
13.0 Reference Documents ..................................................................................................... 88

Tables
Table 3-1 Abbreviations ................................................................................................................ 3
Table 12-1 Wonderware login allowable alarm actions .............................................................. 70
Table 12-2 Alarm filtering minimum settings ............................................................................... 76
Table 12-3 Maximum shelving time by priority ........................................................................ 77
Table 12-4 Example state dependent alarms ............................................................................ 78
Table 12-5 Areas of classification and severity ........................................................................... 81
Table 12-6 Maximum time for response and correction ......................................................... 82
Table 12-7 Alarm prioritization matrix ................................................................................. 82
Table 12-8 Alarm priority to alarm level matrix ......................................................................... 82
Table 13-1 Reference Documents .............................................................................................. 88
Figures
Figure 6-1 Symbols and Identification Systems 1 ................................................................. 29
Figure 6-2 Symbols and Identification Systems 2 ................................................................. 30
Figure 6-3 Process Equipment, Valves, and Pipeline Symbols ........................................... 31
Figure 6-4 Process Symbols and Conventions .................................................................. 32
Figure 6-5 Piping Systems and Equipment Prefixes .......................................................... 33
Figure 6-6 Sample Loop Diagram with Wiring Identification ........................................... 34
Figure 6-7 Installation Details 1 ....................................................................................... 35
Figure 6-8 Installation Details 2 ....................................................................................... 36
Figure 6-9 Installation Details 3 ....................................................................................... 37
Figure 6-10 Existing Control Network Block Diagram Demolition ................................... 38
Figure 6-11 Control Network Block Diagram 1 ................................................................. 39
Figure 6-12 Control Network Block Diagram 2 ................................................................. 40
Figure 6-13 Valve and Gate Control Panel Layouts ............................................................ 41
Figure 6-14 Polymer Fill Station Layout and Elementary Diagram .................................... 42
Figure 6-15 PLC-SN/SS Panel Modifications 1 ................................................................. 43
Figure 6-16 PLC-SN/SS Panel Modifications 2 ................................................................. 44
Figure 6-17 PLC-EA Panel Layout 1 .................................................................................. 45
Figure 6-18 PLC-EA Panel Layout 2 .................................................................................. 46
Figure 6-19 Blower Control Panel 1 .................................................................................. 47
Figure 6-20 Blower Control Panel 2 .................................................................................. 48
Figure 6-21 Blower Control Panel 3 .................................................................................. 49
Figure 6-22 Blower Control Panel 4 .................................................................................. 50
Figure 6-23 Expected General Layout of the P&ID ........................................................... 51
Figure 6-24 P&ID Sample ................................................................................................. 52
Figure 7-1 Control Panel Layout: Front Enclosure View .................................................... 53
Figure 7-2 Control Panel Layout: Subpanel View ............................................................. 54
Figure 7-3 ISB Control Panel Layout: Front Enclosure View ............................................ 56
Figure 7-4 ISB Control Panel Layout: Subpanel View ....................................................... 56
Figure 7-5 Grounding Requirements – PanelView Plus 7 .................................................. 57
Figure 9-9-1 Network Panel Layout .................................................................................. 60
Figure 10-10-1 Cat 5/6 RJ45 Port Locks .......................................................................... 62
Figure 10-10-2 Cat 5/6 Cable Lock ................................................................................... 62
Figure 12-1 ISA18.2 Alarm feedback model ..................................................................... 69
Figure 12-2 Alarm Filtering ............................................................................................... 71
Figure 12-3 Alarm system key performance indicators ....................................................... 74
Figure 12-4 Acceptable alarm rates per operator ............................................................... 75

Appendices
Appendix A – Example Process Control Description
Appendix B – Alarm Management Database
Appendix C – Alarm Management Critical Process Areas

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## 1.0 Revision History

<table>
<thead>
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<td>• Emergency Stop pushbuttons mounted on panels are to be provided with a guard only with an approved NEORSD Deviation Request. Added catalog number for approved guards.</td>
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<td>• For controller tag naming, added emphasis to existing statement, &quot;The site and location shall reflect the physical installed location of the PLC.”</td>
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<td>• Swapped order of Panel Name and Panel Tag. Line 1 to be Panel Tag.</td>
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2.0 Introduction

This manual is a compilation of The Northeast Ohio Regional Sewer District’s (NEORSD) standards for Process Control System (PCS) programming, configuration and design. It is intended to be applied by the District’s contractors, consultants, and in-house personnel when developing or modifying any portion of the District’s PCS. The PCS is a utility-wide system of hardware and software that spans the wastewater collection system and all three wastewater treatment facilities. This document must be treated as both requirements and guidance for PCS work.

This manual is divided into five main volumes:

**Volume 1** contains an introduction to the Process Control System Standards and Conventions Manual. It also comprises District policies and procedures that apply to the use and management of the PCS, including approvals and practices for applying and documenting changes to hardware and software, code changes, alarm management requirements, contractor’s responsibilities related to work performed on the PCS and other related topics. This volume also contains the standards deviation request form.
3.0 Abbreviations

The following is a list of applicable acronyms and definitions which are utilized throughout the Automation Standards and Conventions Manual:

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
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<td>Automatic</td>
</tr>
<tr>
<td>A2ALMDB</td>
<td>Wonderware Alarm and Event Database</td>
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<td>ACS</td>
<td>Area Control Stations</td>
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<td>AMS</td>
<td>Asset Management System</td>
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<tr>
<td>AOI</td>
<td>Add-On Instruction (RSLogix PLC)</td>
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<td>AOS</td>
<td>Application Object Server (Wonderware)</td>
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<td>APM</td>
<td>Automation Program Management</td>
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<td>ATS</td>
<td>Automatic Transfer Switch</td>
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<tr>
<td>BTL</td>
<td>Base Template Library (Wonderware Scripting)</td>
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<tr>
<td>CAD</td>
<td>Computer-Aided Drafting</td>
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<tr>
<td>CAT</td>
<td>Category - relates to communication cable types such as CAT5, CAT6, etc.</td>
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<td>CIP</td>
<td>Capital Improvement Project</td>
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<td>CLX</td>
<td>Allen-Bradley ControlLogix PLC</td>
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<tr>
<td>Abbreviation</td>
<td>Definition</td>
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<tr>
<td>CMMS</td>
<td>Computerized Maintenance Management System (see WAM)</td>
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<tr>
<td>COTS</td>
<td>Commercial Off-the-Shelf Software</td>
</tr>
<tr>
<td>CPU</td>
<td>Central Processing Unit</td>
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<td>CSO</td>
<td>Combined Sewer Overflow</td>
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<td>DAS</td>
<td>Data Acquisition Server (Wonderware)</td>
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<tr>
<td>DASABCIP</td>
<td>Data Acquisition Server – Allen Bradley IP Driver</td>
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<td>DASABTCP</td>
<td>Data Acquisition Server – Allen Bradley TCP driver</td>
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<td>DASMBTCP</td>
<td>Data Acquisition Server – Allen Bradley Modbus TCP driver</td>
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<td>DBA</td>
<td>Database Administrator</td>
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<td>DMZ</td>
<td>De-militarized Zone (IT System Security Layer preventing outside intrusion to PCS)</td>
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<td>DN</td>
<td>DeviceNet - type of field bus network</td>
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<tr>
<td>E&amp;C</td>
<td>Engineering and Construction</td>
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<td>EMSC</td>
<td>Environmental and Maintenance Services Center</td>
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<td>Environmental Protection Agency</td>
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<td>Factory Acceptance Test</td>
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<td>Function Block Diagram</td>
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<td>H</td>
<td>Hand</td>
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<td>HART</td>
<td>Highway Addressable Remote Transducer (Communication protocol feature on some instrumentation)</td>
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<tr>
<td>HMI</td>
<td>Human Machine Interface</td>
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<tr>
<td>H/O/A</td>
<td>Hand/ Off/ Auto</td>
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<td>I&amp;C</td>
<td>Instrumentation and Control System</td>
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<td>Instrumentation–Specific Asset Management System</td>
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<td>IAS</td>
<td>Information Access System (Document Management)</td>
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<td>Identification</td>
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<td>IO or I/O</td>
<td>Input/Output - refers to process signals or signal processing equipment</td>
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<td>Internet Protocol</td>
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<td>International Society of Automation</td>
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<td>Information Technology</td>
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<td>L</td>
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<td>Original Equipment Manufacturer</td>
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<td>One Point Lesson</td>
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<td>Vendor-Supplied Control System</td>
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<tr>
<td>VLAN</td>
<td>Virtual Local Area Network</td>
</tr>
<tr>
<td>WAM</td>
<td>Oracle’s Work and Asset Management Application Software</td>
</tr>
<tr>
<td>WAN</td>
<td>Wide Area Network</td>
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</table>
4.0 Overview
The following sections detail the design standards and provide development guidance for the NEORSD Process Control System (PCS). In general, this section addresses design standards to be used in conjunction with Division 40 specifications to provide consistent designs.

5.0 Process Control Description Requirements

5.1 Introduction
A Process Control Description, or PCD, is a functional statement describing how device-mounted controls, panel mounted controls, PLCs, HMIs, and other processor-based process control system components should be configured and programmed to control and monitor a particular process unit, process area or facility. The PCD shall be included for the contractor’s information and reference in the project Contract Documents as an appendix to Section 40 61 96 PROCESS CONTROL DESCRIPTIONS.

PCDs are sometimes referred to as process control strategies, narratives, descriptions, and other similar names. A PCD is the essential link between process design and control system design. It also forms an integral part of the final control system documentation, providing a concise but descriptive statement that ties together process operation, process equipment, instrumentation, control philosophy, available control modes, and control loops, as well as documenting control logic settings such as setpoints, computed values, alarm limits, normal operating limits, trips, interlocks, and other key parameters.

Process control descriptions serve several purposes:

- During the preliminary design phase of a project, PCDs are used to describe the process control and monitoring concepts based on the conceptual process design. The PCDs document preliminary equipment and operational requirements. At the start of this stage the document may be a PCD or simply process description. At the completion of the preliminary design phase the document should be a well-developed PCD that is about 90% complete.
- During the detailed design phase, PCDs are used to refine process control design requirements such as:
  - Selection and location of instrumentation and control devices
  - Hardwired interlocks and permissives
  - Data archiving and reporting requirements
  - Trend parameters
  - Alarm settings
  - Operator prompts and messages
  - Other functions and parameters associated with the process.
• A PCD provides the instrumentation and control system (I&C) engineer with a guideline for development of the overall design.
• During construction and start-up, the PCDs, in conjunction with supporting drawings, control system lists, equipment specifications and instrumentation information, must be the controlling documents used by integrators and programmers for developing the process control logic and system configuration. The PCDs describe the system functionality that must be installed and tested. Site and Factory Acceptance Test checklists can, in part, be developed from the descriptive material in the PCDs.
• Following the construction testing phase, the as-built PCDs become key reference documents, operation and maintenance manual components, and training materials to provide current, updatable documentation for the technical and operations personnel at the facilities. The design documents should require contractors and integrators to submit as-built documents in native digital format for transportability, accessibility and ease of use on the business network, portable maintenance PCs, and on-line within the control system.

In summary, the purpose of a PCD is to ensure that the process control system is programmed and configured to support the intended operation of the process. The PCDs must convey to control logic programmers and control system configuration specialists how the logic must work, how the process data must be handled, and how the operator must be able to interact with the process equipment.

5.2 Design Coordination
A draft PCD must be prepared during the conceptual process design stage of projects of any project affecting the PCS. The PCD must form a part of any process design report, including the I&C portion of the Basis of Design Report, and its preparation must precede detailed design. This will ensure that the process design can be accommodated within the District’s control hierarchy and philosophy.

To achieve this functionality, PCD development must be an integral component of the process design phase of each project. As such, it requires the participation of both process designers and control system designers. To help establish an ownership role and operator acceptance of the process control system and its capabilities, and to provide designers with greater insight into operators needs and potential issues under operating conditions, the end users should be involved in PCD development and review during the design process, and refinement and testing during implementation.

It is essential that all designers understand and utilize the District’s instrumentation, control and electrical standards, and apply the standards to all control system design products including the PCDs. The District’s standard formats, content requirements and terminology must be used rather than alternate terminology that may be more commonly used by a particular designer or design firm. The District will provide its designers and contractors with access to design, configuration and programming standards that are relevant to each project.
5.3 Process Control Modes

5.3.1 Terminology
Standard NEORSD Control Modes are identified by terms that are combinations of:

- The location from which control actions originate and
- The level of control being activated through selection of a given control mode.

There are several possible location descriptions and several possible levels of control that, in combination, form a control hierarchy, from simple manual starting and stopping of single devices to complex automation of process areas and facilities.

For interpretation of abbreviations and terminology used in this NEORSD Design Standard as well as additional process control system terms that may be useful, refer to the Glossary in Section 3.0 of this volume.

To help standardize the content of PCDs developed for NEORSD under all projects, including in-house system modification and development and out-sourced design, integration and technical assistance projects, the following process control mode definitions and conventions must be employed:

5.3.2 Control Location definitions:
- LOCAL Local controls are those that are nearest to, and typically in the immediate area of, the controlled device. In some cases local controls are integrated with a device’s actuator or adjacent electrical disconnect panel. An example would be a valve actuator with “Open”, “Close” and “Stop” buttons or switches, and in most cases a “Remote/Local” selector switch that enables operation from either the local pushbuttons or a remote control signal source. However, in cases where a gate, valve, blower, or other controllable device is located in an inaccessible or hazardous location, the local controls may be in an auxiliary control station that is mounted in a safe, accessible location, some distance from the device.

- REMOTE A control station location that is not in the immediate vicinity of the controlled device, or, if there is more than one tier of remote control for a device, a control location that is remotely located from a lower tier control station.

- PLC/PAC or RTU Control actuated via the process control system through remotely located HMIs, OITs, control processor logic, or other interface devices.

5.3.3 Level of Control definitions:
- MANUAL Human, hands-on, control of equipment functions via an enabled manual control station; e.g. switches, pushbuttons, dials, manual loading stations, OITs, HMIs.
5.3.4 Control Mode Definitions:
Control mode definitions for NEORSD wastewater collection and treatment facilities, arranged in hierarchical order by combinations of control location (Section II.B) and level of control at the location (Section II.C), include:

- **LOCAL**
  - **LOCAL MANUAL**  
    Manual control via devices located at or near the controlled equipment.
    
    Examples:
    - Valve open and close pushbuttons on an actuator or a local control station/local control panel (LCS or LCP).
    - Motor start and stop pushbuttons on a motor drive or electrical switch enclosure near the motor.
    - Motor variable speed adjustment potentiometer at a motor drive or on a power panel.

    Note: in some cases the local controls may be mounted an extended distance from the device for safety and accessibility.

  - **LOCAL AUTO**  
    Automatic control implemented at a local control panel in the area of the controlled device.
    
    Examples:
    - Panel-mounted single-loop flow controllers with manual setpoint adjustment
    - Pump on/off control based on local level signal settings or float switches
    - Timers that cycle sludge pumping
    - Other similar controls that require limited or no operator interaction.
- **REMOTE**
  - **REMOTE MANUAL** Manually entered control exercised at a location that is not in the vicinity of the controlled device(s).
    
    **Examples:**
    - Stop/Start, manual adjustments and Open/Close commands entered at remote pushbuttons or non-HMI/OIT operator interfaces.
    - Manually adjusted variable speed control at a VFD panel.
    - Any control actions that are manually initiated from a remote panel in a process area that are not routed through a PLC.
  - **REMOTE AUTO** Automatic control without frequent manual intervention or process control system interaction.
    
    **Examples:**
    - Automatic speed modulation by panel-mounted loop controllers.
    - Automatic start/stop or open/close control processed by field mounted device controllers, limit switches, timers, etc.

- **PLC/RTU**
  - **PLC (or RTU) MANUAL** Manually entered adjustments and commands via HMIs or OITs such as start/stop, open/close, increase/decrease, etc. emulating LOCAL MANUAL but processed through the PLC system.
  - **PLC (or RTU) AUTO** Automatic control actions generated by computers and PLCs in response to inputs to the PCS system such as monitored level, flow, density, on/off status of equipment, etc.
    
    **Examples:**
    - PLC-based closed or open loop controllers with operator entered or computed setpoints or output values
    - Cascaded PID control algorithms
    - Computer or PLC-based supervisory control of multiple loops, cascaded loops and more complex flow distribution algorithms, chemical feed rate based on ongoing computations, and level control algorithms. These algorithms may or may not require regular operator intervention such as ratio adjustments, setpoint adjustments, lab generated data, etc.

**NOTE:** Not all control modes will be implemented for every process under every project. Available control modes will depend on design and operational factors such as whether a location is normally staffed or unstaffed, the type of process being designed or modified, whether vendor-provided, pre-packaged and pre-programmed PLCs and panels are provided with the equipment, and the degree of automation desired by the District. The designer must
prepare PCDs that are relevant and appropriately aligned with each project’s conceptual design and operational constraints.

5.4 Control Strategy Determination and Design

For any given process and associated control location, the appropriate control modes must be identified and designed into the instrumentation, control devices, panels, control logic and operator interfaces. This should be a collaborative process involving workshops that bring together process engineering, operations, instrumentation and control system engineering, electrical and hydraulic design and other stakeholders whose input is essential. The workshops should help the designer achieve a clear understanding of the existing control system structure and functionality, as well as the District’s desired level of process control and monitoring capabilities to be achieved under the project.

At both the treatment plants and Collection System sites, sections of the PLC panels or Main Control Panels (MCPs) that house PLCs or RTUs will accommodate panel mounted OITs that provide process information as well as controls, so the need for extensive panel-mounted manual control switches and indicators is less critical than in the original NEORSD process control designs that pre-date the PCS. However, the need for manual backup control in certain critical locations should be evaluated for all new projects. If local manual backup controls are not critical, MCP level control can typically be provided through an OIT with the same or greater functionality, and unused local control panels or sections of panels can be eliminated.

The District may determine for a given project that control stations will be needed in cases where the operators must have clusters of manual controls to maintain control of critical process equipment if a PLC is out of service. If any, these must be identified during the detailed design. Such control stations will need to be hardwired into process and equipment control circuits to provide adequate functionality independent of the PLC when needed.

By properly configuring and programming the control system so the PLC or RTU maintains control of the local process if there is a network or HMI failure, process equipment status should not be adversely affected when a failure occurs. Provision of resilient uninterruptible power to PLCs, servers, and RTUs is essential. Hard-wired, panel-mounted controls that require additional panel space, expense and maintenance may not be required in many cases.

Designers should not propose to eliminate any manual control at existing local device panels. However, where the project scope permits, designers should include specification requirements to eliminate abandoned, unused conduit, electrical and signal wiring, and abandoned control and communications enclosures and panels. The goal is to reduce control ambiguity, simplify maintenance and expansion, improve esthetics and make efficient use of available space.

5.5 Process Control Description Content and Structure

5.5.1 General Requirements

- The PCD developer should always bear in mind that the PCDs for a project are the primary source of information used by the programmers for developing process control logic. Well-developed PCDs minimize Requests for Information. The PCD should be
clear, cover normal and abnormal operation, and should elaborate on the interactions between operators and the control system.

- When developed within capital design, technical services, integration or construction projects, PCDs should be prepared, submitted and reviewed under the same submittal process as that employed for other portions of the project.

- Under design projects involving more than process control and monitoring and requiring a Basis of Design Report, the preliminary draft PCDs should be included as a section of the Report. For projects that predominantly involve the process control system, the PCDs should be submitted in a stand-alone document accompanied by supporting documentation referenced in the PCD.

- PCDs should not include project or process documentation that is otherwise available for reference. For example, I/O lists, instrument lists, and lists of calibration settings should not be included, but should be referenced. To avoid conflicts, ambiguities, and the need to maintain multiple versions of the same information, never include process control and instrumentation information that is available elsewhere. Future updates to PCDs should be based on the latest system documentation and not on outdated information that may be embedded in the PCD itself.

- PCDs must be written in accordance with all relevant District Standards (e.g. Standard HMI and OIT objects, standard PLC/PAC AOI objects, control hierarchy, philosophy, software development techniques, general requirements, etc.), and must reflect the requirements of the standards. Wherever possible, references must be made to the relevant section of the standard rather than repeating the requirements.

- The primary author of the PCD should be a process control system engineer. However, the PCD must be developed in cooperation with and with input from the process designer and the District’s Operation and Maintenance Department and Engineering and Construction Department staff. The intent of this is to ensure that the control system reflects not only District Standards, but the specific operational needs and requirements of each process and facility.

- The conceptual or draft PCD must be updated during detailed design to reflect the final control arrangements documented in the contract drawings and specifications. Updated PCDs must form the basis of contract negotiations for software development.

- It is important to define in the PCD which settings, limits and other parameters may be changed by the operator and which may only be modified by supervisors or others with higher level clearance. It should also be clear which settings can be accessed and changed through the HMIs or OITs and which require a control logic programming change.

- The designer should include the District’s specification Section 40 80 01, Process Control System Post-Commissioning Tuning and Optimization Support Service, requiring the Contractor to modify settings and make other types of functionality changes after a period of operational familiarization (Refer to NEORSD Standard Specifications Library). The entity responsible for the control logic programming must be responsible for performing any post-commissioning PLC programming, HMI and OIT changes. Responsibility for updating the PCDs to reflect all field-implemented and post-
commissioning changes shall be as defined in Section 40 80 01 or as otherwise contractually specified.

- The PCD author should reference actual point tags when necessary to avoid ambiguity. For example, it may be better to state “Shut down and inhibit starting Pump 2 if wet well level switch S02_L002A is in a low alarm condition” than to simply refer to a low level condition if there are multiple level switches with similar but separate functions.
- The PCD author should include alarm priorities to avoid ambiguity. Reference alarm management policies in Section 10.0.
- During project implementation, it is imperative that the PCD is updated to reflect process/field changes. Every attempt must be made to identify changes prior to completion of shop and site testing. Following software development and testing, commissioning and acceptance, the final PCD must be prepared and issued to reflect the as-constructed situation.
- The PCD author should define the power failure and recovery conditions for each piece of equipment and the subsequent action. The power failure state will depend on many factors, including utility power failure, generator power failure, UPS power to PLC failure, etc. and available statuses (i.e. PLC inputs). Reference Section 16.3 of Volume 2 for further details.

5.5.2 PCD Document Outline
The following standardized PCD document outline must be used to provide the District with uniformly structured process control documentation.

The PCD for each controlled and/or monitored process must include the following components:


Part 2. Revision History – Version, Date, Author, Version or Change Description

Part 3. A reference list of specific relevant drawings and schedules that augment understanding of the process control and monitoring described by the PCD, including, as appropriate:

- Site and Equipment Location Drawings
- Network Architecture (Control System and project specific architectures)
- Electrical Drawings
- Process Piping and Process Flow Diagrams
- Process and Instrumentation Diagrams (P&IDs)
- Loop Diagrams
- I/O Lists
- Instrument Lists
- O&M and Vendor-furnished Manuals

The references should not be general, but should list specific drawing numbers and document titles from within overall design packages. New drawings produced under the project, as well as existing drawings that are used to augment the design documents, should be listed if relevant.
Part 4. A description of the process or facility that clearly explains what equipment and treatment is involved, how the process or facility should operate under various conditions, and its relationship to parallel, upstream and downstream processes.

Part 5. A general description of process control strategies and control modes that are available for each process unit, the major hardwired and virtual process variables, and the types of data collected by instrumentation in the area.

Part 6. Detailed descriptions of the control algorithms and strategies that must be programmed in the PLC, PAC or RTU control logic (e.g. pump duties, equipment sequencing, process control loops, etc.) This section should describe all relevant control philosophies, interlocks, settings, limits, levels and modes, e.g.:

- Control Settings
- Operator Security Restrictions and Permissions
- Local and Remote, Auto and Manual Control Modes
- Specific Device Control Characteristics
- Interlocks (Process, Emergency, Safety)
- Permissives/Trips
- Manually Entered Points
- Virtual and Computed Points
- Handling of bus-connected devices and associated controlled and monitored points (DeviceNet, Modbus and other types of device communication links)
- Control Strategy Activation and Initialization
- System Generated Operator Messages and Action Prompts
- Control Mode Transference
- Failsafe Mode and Actions
- **Power Failure Recovery Conditions/Actions**
- Communications
- PID Loops and Advanced Control Algorithms
- Events
- Alarms/Alarm Priorities
- Runtime and/or Start Count tracking

Part 7. Locations and Identifiers for Associated Processors, HMIs, OITs, Control Panels, Control Rooms and Communication Cabinets

Part 8. HMI and OIT Display Descriptions

- Overviews
- Area
- Equipment Detail
- Tabular Data
- Control System Status
- Electrical System Status
• Other (weather, informational, video monitoring)

Part 9. Trend Display Details

• New Trend Menu/Index Items
• Descriptive Information for each Trend to be Developed
• Database points included in each trend
• Time scale/span
• Axis labels
• Links to other trends or displays


Specify alarm priorities where possible for the programmers’ use in constructing alarm tables, displays and reports

Part 11. Report Descriptions

• Preconfigured On-Demand Reports
• Scheduled, Automatically Activated Reports

Additional sections should be included as deemed necessary by the designer to fully describe the process control approach, control logic details, displays, trends and other operational requirements.

5.6 Specific PCD Development Requirements

5.6.1 General Control Functions

• The process control logic shall include the features and functions described herein. The process design shall facilitate and support the needed control and monitoring functionality.

• The following terms are typically referenced in the PCDs:
  
  o **Operator Adjustable**: Operator set, entered or adjustable values that are modifiable via the PCS HMI and OIT graphic display operator entry field. Example of operator set or entered values are process setpoints, valve position manual outputs, pump cycle times, etc. Specific variables that are required to be operator adjustable are noted in the PCDs.

  o **Tunable Values**: Tunable values are constants that are adjustable by personnel at authorized staff levels based on system log-in rights, without requiring any software reconfiguration. Examples are high, low and other alarm limits, start/stop settings, alarm time delay function, etc. Tunable values are noted in the PCDs.

• Various control modes are available for the process equipment, sub-systems and ancillary equipment as outlined herein. Equipment that may be controlled either locally or by the PCS will be equipped with L/R (Local/Remote) mode selector switches, and those equipped with local hardwired manual control and PLC monitoring will be equipped with H/O/A (Hand/Off/Auto) or M/A (Manual/Auto) mode selector switches.
- For PLC controlled equipment, placing the L/R selector switch in the Local (L) mode will enable control via the LCP start/stop pushbuttons; Remote (R) mode will transfer control to the associated PCS processor for operator access via the PCS HMI and/or OIT.
- For equipment without PLC control, the H/O/A or similar mode control switch in Hand (H) mode enables control via the LCP start/stop pushbuttons and other controls; Off (O) stop an active unit; Auto (A) mode transfers control to actuation via field-mounted devices that trigger control actions, i.e. level switches, pressure switches, etc.
- An Emergency Stop (E-Stop) shall perform an immediate stop of the associated piece of equipment. Panel-mounted E-Stop pushbuttons shall be installed without guards. If a guard is requested, then a deviation request must be filled out and approved. When panel-mounted E-Stop guards are approved, they shall be Allen-Bradley catalog number 800T-N310 or equal. Field-mounted E-Stop pushbuttons shall never be installed with a guard.
- In all cases, neither the Local or Remote control mode switch positions shall disable any hardwired safety or equipment protective circuits such as emergency stop circuits, low level pump trips, high level alarm strobes, high vibration trips, etc.
- Analog Control Loops: Analog control loops shall operate based on a standard PID controller, with the controller faceplate incorporated on the PCS HMI graphic display. The PID controller must include, at a minimum, bar graphs for setpoint, process variable and percent output, poke point buttons for Auto/Manual Mode selection, and a numeric entry field with popup keypad for Operator entered values.
  - The PID controller faceplate includes (but not limited to) the following functions:
    - Auto/Manual Mode selection: In Auto Mode, the output of the controller is based on the PID controller calculation. In Manual Mode, the output of the controller is operator adjustable. Switching between the PID controller’s operational modes shall be configured with setpoint tracking and bumpless transfer.
    - Compound Mode: (where applicable) In the Compound Mode, the setpoint is trimmed by a remote setpoint input. This mode is used in applications requiring a cascade control loop such as level/flow.
  - PID controller faceplate contains setpoint value, process variable, mode status, and controller output and deviation alarm indication.
  - When in the Automatic Mode, PID algorithms shall monitor the margin of error between the setpoint value and the actual process variable. A deviation of +/- 10% between setpoint and process variable generates a Deviation Alarm notifying the operator of the condition. The % of deviation is a Tunable Value.
- All motors (constant and variable speed) must be monitored for the associated Run, Stop, and Fault status. When the PCS initiates a run command output, the PCS logic monitors the running status feedback from the motor (starter or variable speed drive) and produces a Fault Alarm if the motor feedback does not correspond with the status of the PCS initiated command output. A PCS internal delay timer with typical preset of 15 seconds shall be configured for each logic statement to allow the motor control adequate time to comply with the output command. The timer preset is a Tunable Value.
• All valves and valve actuators with position feedback are monitored for the associated Opened and Closed statuses. When the PCS initiates an Open/Close command output, the PCS logic monitors the position feedback and produces a Fault Alarm if the valve feedback does not correspond with the status of the PCS initiated command output. A PCS internal delay timer preset of 60 seconds is configured for each logic statement allowing the valve actuator time to comply with the output command. The timer preset is a Tunable Value and requires adjustment at startup depending on the type of valve or gate and the full open to close travel time for each.

• When activated, all critical, high priority alarms (e.g. Eyewash/Shower Station Activation alarms, E-stop Initiated alarms) shall be prominently displayed on the PCS HMI graphic displays and in the alarm banner. An Emergency HMI graphic display shall be dedicated to show the location, description and status of each of these high criticality alarms.

• All Uninterruptible Power Supplies (UPS’s) shall be monitored for, at a minimum, loss of utility power, automatic transfer switch (ATS) status, fault, low battery, reverse transfer, and common alarm. All alarm and status conditions shall be shown on the appropriate PCS HMI and OIT graphic displays as required.

• For equipment with PCS control, a Fail or Fault alarm will be initiated if the equipment does not respond to a PCS output command, as outlined above. In this event, the PCS output command is de-energized subsequent to the expiration of the alarm delay time period, i.e. a timed-out command.

• Running, Stopped, Fault, Failed, Opened/Closed statuses as well as position and speed indication of equipment shall be indicated on the appropriate PCS HMI graphic display and/or Control Window. Other signals are included on the PCS HMI graphic display as noted in the specific PCD sections and I/O List.

• Analog inputs shall have a signal Out Of Range Alarm generated via a PCS internal timer when the PCS input is < 3.8 mADC or > 20.5 mADC. The alarm delay timer preset is initially set at 20 seconds. The delay preset value is a Tunable value.

• Discrete inputs shall be alarmed as noted in the specific PCD sections.

• Where alarms are specified in the PCDs, they are initiated from the associated PCS inputs. If discrete inputs are not available for a required alarm condition, the specified alarms are derived in the PCS logic using internal coils and contacts, i.e. solenoid valve not equipped with open/close limit switches shall use the open/close output to indicate the assumed position of the valve.

• Process switches that are inputs to the PCS shall be programmed as follows. Upon activation of the process switch, the PCS shall confirm the input by use of an internal delay timer with an initial preset value setting of 15-seconds (Tunable Value). When the timer’s accumulated value equals the preset value (i.e. timed out), the PCS logic generates the associated alarm. Some, but not all, process alarms act as interlocks to shutdown equipment, as noted in the specific PCD section, and as shown on the equipment’s elementary schematic. When the alarm is activated, the operator should take corrective action as needed to best maintain safe operation.

• All flow inputs shall be totalized (integrated) and logged on the PCS historian. All totalized values are displayed on the PCS HMI graphic display in the appropriate engineering units as required. Provide daily flow totals for all measured flows.
• Equipment run times and/or start counts may be totalized, displayed and logged on the PCS historian. Work with the District during the development of the PCD to identify the motorized equipment that require tracking of runtimes and/or start counts. Run times shall have a resolution of one-tenth of a minute and be displayed on the appropriate PCS HMI graphic display as well as the OIT. For a motor to which the runtime and/or start count tracking has been selected, the values below will be displayed on the OIT and HMI screens on which the motor’s symbol appears. Some values will be shown on the process overview screen while others are accessible by opening the motor faceplate.
  o Current Day’s Runtime (max 23.9 hrs)
  o Previous Day’s Runtime (max 23.9 hrs)
  o Current Run Cycle Elapsed Time (max 9,999.9 hrs)
  o Previous Run Cycle Elapsed Time (max 9,999.9 hrs)
  o Total Elapsed Runtime (99,999.9 hrs)
  o Current Day’s Start Count (999 starts)
  o Previous Day’s Start Count (999 starts)
  o Total Start Count (999,999 starts)

• Controls shall be grouped together functionally on the PCS HMI graphic displays for ease of process status recognition, operation and navigation. Both analog and discrete functions associated with the process equipment or area grouping of process equipment shall be located on the same PCS HMI graphic display where practical.

• For each piece of process equipment controllable by the PCS, an equipment “ready” or control mode permissive signal is needed to indicate to the PCS control logic PCS control is allowed. The PCS shall monitor the Local Control Panel mounted L/R mode selector switch and control the equipment that is in the Remote mode.

• All motors equipped with a solid state motor overload relay and/or a single-phase relay (SPR) for phase loss detection shall generate a respective FAIL alarm in the event of a failure signal from the relay. This alarm must be indicated at the Local Control Panel and the PCS HMI graphic display. Reference the Electrical elementary schematics and I/O List for requirements of the Fault conditions.

• The solid state motor overload relay shall also monitor any additional I/O List signals and shall include I/O register mapping for the Ethernet/IP network communications.

• Non-modulating actuated (motorized) valves shall be controllable via Open-Stop-Close buttons on HMI and OIT faceplates. The valves shall be controlled in the Open and Close directions by separate PCS momentary control signals, which are latched in the actuator. The PCS shall stop the Open or Close command to the actuator when the actuator reaches the respective end of travel.

• I/O points shown in the PCS portion of the P&IDs and I/O List must be incorporated into the PCS HMI and OIT graphic displays as indicated by their function.

• Operator entry of setpoints shall be limited to values within upper and lower operating limits corresponding to the valid operating range of the equipment. An operator-entered setpoint outside the valid range must be rejected by the PCS and the original setpoint shall be maintained until a valid value is entered. When an invalid setpoint is entered into the system, an Invalid Value message shall appear in the setpoint entry faceplate, alerting the operator to the condition. The upper and lower range limits are Tunable.
- All gate and valve actuators provided with Ethernet communications shall have their respective I/O registers mapped into the PCS for monitoring and control. In most cases, not all available parameters from actuators will need to be monitored. The P&IDs must be referenced to determine the input and output parameters that will be available for valve and gate control and monitoring.

- Where vendor packages are supplied as part of the Contract, the vendor packages that are supplied with a PLC-based Vendor Control Panel (VCP) shall be programmed by the vendors for integration into the PCS via the facility LAN connection.
  - Certain vendor packages may require no remote operator input and no remote PCS control while other vendor packages include select functions from the remote PCS. In either case, all available vendor package I/O points shall be integrated into the PCS for display, alarm, and monitoring. Reference the particular PCDs, P&IDs and Contract Documents for PCS interface requirements.

- Substation PLCs shall NOT be used for any type of process control. Substation PLCs are used for monitoring only.

5.6.2 PCS Failure Modes

- **PCS HMIs / OITs**
  - PLC programs shall be capable of functioning normally in the absence of a PCS HMI or OIT without any special modifications. PLC logic, including monitoring, control, and alarming functions shall be programmed at the PLC level only; process control logic at the HMI level is not permitted.
  - Each PCS HMI and OIT shall be an independent device with a dedicated network connection.
  - A failure of one PCS HMI or OIT shall have no effect on other PCS HMIs or OIT or the PCS as a whole.
  - Should all HMI nodes fail, the PCS shall continue control functions independent of the node status and based on the last valid information received from the PLC. However, where needed, and as appropriate, loss of communications between any PLC and the HMI network should result in a controlled fail safe process shutdown.

- **PLC**
  - Software watchdog timers, incorporating a “heartbeat” routine, shall be included to monitor the condition of each PLC processor and all network hardware.
  - PCS (or PLC processor) failures shall be indicated on the appropriate PCS HMI graphic display.
  - Independent watchdog routines shall include, but not be limited to the following:
    - PLC and Power supply failure
    - PCS network component and communication failure
    - PCS hardware component failure
  - In the event of a PCS component failure (rack, I/O module, communication card, etc.), all affected PLC discrete outputs shall fail to the appropriate state
(energized/de-energized). Affected analog outputs shall fail high, low or hold last value as long as power is available.

- PLC Clock Synchronization shall occur once per day. At a predetermined time, the hour, minute and second PLC registers shall be synchronized with the master facility or PCS clock.

- I/O MODULES:
  - The PCS shall have internal diagnostics that detect and report I/O module and point failures. Module failures shall be indicated on the appropriate PCS HMI graphic display.

- PCS MONITORING
  - A System Status graphic screen is required for monitoring the operational status of the PCS network, network devices, control processors, servers, local and remote I/O modules, and all other network-attached PCS equipment. Any system or hardware faults shall be indicated on the graphic screen so the appropriate action may be taken.
  - Backup Battery Power: The PCS (PLCs, RTUs, HMI, OIT and network gear) are powered by UPS units. The PCS will continue to operate during a power disruption for a limited time, typically not more than 30 minutes, to control and monitor the process, and monitor the status of system equipment until the return of utility power. The UPS shall provide backup power to all essential 4-wire transmitters and to power supplies in the PLC/RTU panels that provide power to 2-wire devices.

- POWER CYCLE OR FAULT - EQUIPMENT RE-START
  - The typical NEORSD facility has two utility power feeds plus emergency generator backup. However, in the event that the power to operate the process is completely lost, the process equipment will go off line until the power feed is restored. The subsequent sections describe equipment re-starts after power transition or failure.
    - Equipment furnished with an H/O/A selector switch (i.e. not controlled by the PCS) will not need to be re-started after a power transition. After a power transition has occurred, the equipment will resume operation based on the status of the associated field interlocks, i.e. a high level switch activating a sump pump. If the power transition caused an equipment alarm, the alarm must be reset prior to the equipment resuming functional operation.
    - Equipment furnished with an L/R selector switch (i.e. controlled by the PCS) shall NOT automatically re-start after power returns unless otherwise indicated in the specific control strategies. Unstaffed facilities will typically require automatic restart of pumps and other necessary process equipment. Automatic re-starting of multiple process units with large motors shall be staggered so that the power system is not overloaded by in-rush current from several items being started simultaneously. Equipment re-start order shall be prioritized based on the process operations.
• When equipment operating under PLC-Automatic mode has been stopped (shutdown) due to an alarm condition, its PLC start/stop output shall automatically be switched to Stop and the equipment switched to Remote-Manual to prevent immediate automatic restart when the alarm is cleared.
  o In some cases, manual reset of alarms and manual restarting of equipment may not be practical. As needed, particularly in unstaffed remote facilities and in process areas that require it, the PCS shall be able to restart equipment in an orderly and controlled manner to prevent hydraulic surges and electrical overloads. Multiple large motors shall not be simultaneously started.
  o In all cases in which the PCS starts equipment and initiates PCS Automatic control, the control processor shall execute an initialization routine to allow bumpless resumption of service.
• When equipment is tagged Out Of Service in the PCS by an operator via either the HMI or OIT, all associated ancillary equipment shall have their alarms inhibited until the tagged-out equipment is returned to an Available for Service status.
• When a running piece of equipment is stopped by an operator or by the PCS control logic, associated PCS alarms such as low flow, low pressure, and other possible conditions that are normal under a controlled shutdown shall be suppressed.

When equipment has been stopped (shutdown) due to an alarm condition, the alarm must be manually acknowledged and cleared by the operator. The PCS logic shall be developed such that the equipment that was stopped can be reset to clear the alarm and restarted at the OIT and locally.

5.7 Example Process Control Description
An example is provided in Appendix A to convey the NEORSD standard PCD approach.

6.0 Process and Instrumentation Diagrams (P&IDs)

6.1 Introduction
The following guidelines should be used in the development of Process and Instrumentation Diagrams (P&IDs) for the District. The P&ID is the foundation for any process design and should be developed and finalized before the 60% design submittal. Additional changes to process and the instrumentation can be made; but modification of the P&IDs after the submittal will include additional coordination with mechanical, electrical, and process design team members.

6.2 Background
P&IDs are schematic contract drawings showing the mechanical, electrical, and instrumentation elements of a process. They supplement the overall process flow diagram and hydraulic profile drawings (each is usually a single sheet) produced in District designs. P&IDs are produced jointly by the process design engineer (civil/sanitary/environmental/mechanical/chemical) and the project controls engineer and should be developed as the first stage of the design to define
all of the elements of a design before process mechanical and civil piping layout work commences.

- The key to the successful use of P&IDs is that they become the source of all project information. Other key project documents, including detailed piping layouts and mechanical details, equipment data sheets, process measurement and control requests, instrument list, I/O list, and detailed specifications, are developed from the information found on the P&IDs.
- P&IDs are used to improve communications among the design team, the client, and project reviewers. By generating the P&IDs first, all project participants can understand the design intent.
- P&IDs are used to involve electrical and controls engineers, including internal project staff and consultants, earlier in the design process. The P&IDs provide a common tool for collaboration and discussion about design elements.
- P&IDs can be used to promote standardization of design within the District, so that more engineers from different firms can work together on larger projects.
- The use of P&IDs improves overall quality assurance. Since the P&IDs function as the project's primary source document, they are also the key document for quality assurance reviews.
- P&IDs provide a schematic overview of plant processes and can provide operations and maintenance staff an effective tool for troubleshooting and maintenance.
- P&IDs can be used as a tool to enhance production of operation and maintenance (O&M) manuals and to facilitate startup and training efforts. Because of the reduced complexity, operators can frequently understand the design intent better from P&IDs than mechanical layout drawings.

6.3 P&ID Development
An overall Process Flow Diagram (PFD) is the first document to be developed for any design project. The PFD will be completed with process quantities (average, maximum, minimum) for all principal process liquid, solid, and gaseous streams. Minor process streams such as chemicals, etc., are shown by inputs and maximum/minimum quantities. Hydraulic calculations for all major process streams should also be started at this point in a project and developed to a draft level for review.

6.3.1 P&ID Development Responsibilities
Specific responsibilities for P&ID production are summarized below.

<table>
<thead>
<tr>
<th>Role</th>
<th>Responsibilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Manager</td>
<td>Ensure that P&amp;IDs are prepared, coordinated between all applicable disciplines, and QC checked.</td>
</tr>
<tr>
<td>Project (Process) Engineer</td>
<td>Develop piping schematic of process unit. Lay-out P&amp;ID presentation on drawing. Identify key instrumentation features. Provide interlock notes. Review P&amp;ID, together with control strategies, control requests, and process measurement requests, with the controls engineer. Keep the controls engineer informed of changes. Review</td>
</tr>
</tbody>
</table>
instrumentation design with the controls engineer on a regular basis.

Controls Engineer

Review P&ID with the process engineer. Add motor starting equipment, control panels, PLC, HMI interfaces, and instrumentation features per control strategy, control request, process measurement request. Mark up P&IDs to depict instrumentation and control functions. Consult with process engineer on instrumentation revisions. Provide I/O address numbers where programmable logic controllers used for control.

The next step is to review and update the standard P&ID symbols sheets for the project. Standard mechanical and piping symbols, instrumentation and control interlocking, and process line abbreviations are shown on the initial sheets. The District has standard legend, symbols, and abbreviations sheets which are included in Section 6.7 and Section 6.8 of this document. Space has been provided under each category for project-specific symbols and abbreviations when it becomes necessary. It is suggested that the design team limit these to only those absolutely necessary.

Equipment identification tables should be located adjacent to mechanical equipment and list the following information:

- Equipment name.
- Equipment number.
- Equipment type (if not adequately defined by the symbol used in the legend).
- Specification section.
- Nominal rated conditions.
- Motor rating.

Once the PFD, the preliminary hydraulic calculations of major process streams, and the P&ID symbols sheet have been prepared and have been reviewed by process specialists, development of the P&IDs can then be started. No changes to the project should be implemented unless those changes are first reflected on the P&IDs.

6.3.2 P&ID Presentation

Each process unit or utility system is shown complete with all mechanical equipment, piping, instrumentation, and control interlocking. A minimum of one P&ID is provided for each process unit. If a single P&ID is too crowded or complex, the responsible engineer (usually the controls engineer) can split the P&ID into multiple sheets. The following general guidelines should be adhered to unless the design team determines that it make logical sense to deviate from these guidelines. All P&IDs are schematic in nature and are not drawn to scale. Each P&ID should have a call out indicating that they are not to scale.

6.3.2.1 GENERAL LAYOUT PRESENTATION

A P&ID sheet is typically divided into roughly thirds horizontally. The lower third used for process streams, the middle third devoted to local panels, actuators, MCCs and associated equipment. The upper third, which is separated from the other areas by a horizontal line, shall
include the PLC I/O, HMI/OIT data displays, and process electrical and instrumentation signaling and equipment. The PLC I/O and HMI/OIT data is then subdivided into two areas by a horizontal line. To allow adequate room for depicting instrumentation, the process engineer is discouraged from crowding a P&ID with process equipment and piping.

The process is presented with primary flow generally from left to right and from top to bottom on the drawing. Secondary flows may be from right to left. The process unit is portrayed in sectional view and consists of associated major and minor equipment and primary and secondary process lines (i.e. pressure vessels, pumps, blowers, heat exchangers, valves, etc.). Process line referencing is provided by flags showing flow direction, located along the left and right side of the drawing's process area. Process line descriptions consisting of the line size, line service abbreviation, line material abbreviation, line number (as applicable) and design flow rate, are placed next to the flags. Size and/or flow information is noted wherever flow branches occur along the process line. Vertical process lines are broken where they cross horizontal process lines. In the case of steam, where several parameters are required to describe the process flow, the flow point may be denoted by an alphanumeric symbol referencing a table of parameter values. Process lines should be either vertical or horizontal; angled lines should be avoided where possible. Piping orientation does not need to follow the proposed physical layout.

Multiple, identical process units are treated as individual process units on sequential P&IDs. Equipment or instrumentation that are common to several process units are shown on the first P&ID of a P&ID sequence. To the extent practical, process flow, instrumentation signal, and control interlocking lines are carried between sequential sheets at the same elevation on the sheet so that when the sequential sheets are placed together they will form a coordinated P&ID. Process, instrumentation, and control lines continuing to non-sequential sheets may be placed at any convenient elevation on the sheet. Continuation of process, instrumentation, and control lines from sheet to sheet is indicated with label arrows that have corresponding arrows on the connecting sheet. Continuation box shall contain the destination P&ID drawing number. Arrowhead shall contain an alpha character to match with destination on the destination P&ID. Destination P&ID continuation box shall reference source P&ID drawing number and arrowhead shall have matching alpha character.

For a full-size drawing, a minimum of a 6-inch wide by 3-inch tall square on the right side of each P&ID is reserved for notes, interlock information, control descriptions, and the continuation of the revisions block (if required). The revision block space may be used to record all revisions, beginning with the original draft. Letters (A-Z) will be used to denote the revisions until the drawing is issued for bidding purposes. All alphanumerical revisions noted during design are removed when P&IDs are issued as a part of the construction contract documents. Once the drawing is issued, modifications to the issued drawings shall then be denoted by numbers (1-9), starting with “1”, and then “2”, and so on.

6.3.3 Instrumentation Presentation
Process and equipment control and/or protection instrumentation are shown using standard International Society of Automation (ISA) symbols and function identification letters.
The appropriate type of signal line (i.e., pneumatic or electrical signal, capillary tubing or process tap, etc.) connects individual instruments together into control loops. All instrumentation is shown, including process sensing devices (pressure or temperature switches, flow elements, magnetic flow elements, weirs, etc.), their transmitters or signal converters, controllers, special function instruments (i.e., multipliers, summers etc.) and final process control device (i.e., valves, adjustable speed controls, heaters, etc.). Control devices (i.e., mode of operation selector switches, etc.) mounted on operators’ panels should be described as instruments on the P&IDs. Major control functions for devices on local control panels, motor control centers, and VFDs will be shown on the P&ID also.

Instruments which have special functions (i.e., totalizers, multipliers, E/P, l/P, etc.) are shown by placing the correct instrument function designation next to the instrument, in accordance with ISA-5.4, Figure 6-1.

Instrument symbols also denote the type of instrument (i.e., discrete, multifunction shared, computer function, etc.) by use of the appropriate ISA symbol.

**6.3.4 Control and Instrumentation Interlocking**

Control and instrumentation interlocking is shown using the ISA interlock symbol. A numeral placed within the diamond symbol will be used to reference a brief description of the required interlocking. The description is placed in the right hand side of the drawing in the space reserved for that purpose. Tables may also be used to describe more complicated interlocking.

**6.3.5 Packaged or Vendor-Supplied Control Systems**

Packaged or Vendor-supplied Control Systems (VCS), supplied with a Vendor Control Panel (VCP), that are to be furnished as a part of a pre-engineered mechanical equipment package are shown as a rectangular symbol with its equipment number placed inside the rectangle. A solid black diamond is included within the rectangle to visually identify the equipment as a vendor supplied package. The VCS symbol is connected to the mechanical equipment symbol by the appropriate signal lines (i.e., pneumatic, electrical, hydraulic, etc.). Instrumentation supplied as a part of the VCS which must interconnect with the process control and/or instrumentation system is shown outside the VCS symbol, assigned ISA function identification letters followed by the equipment number, and shown interconnected to the appropriate system. A brief description (vendor identification, function, etc.) of the packaged control system is provided in the notes or interlocking area of the drawing.

**6.4 Interface with Process Control Descriptions**

Control strategies describe in narrative form the detailed operating parameters and functionality of each discrete process area. They should be written in coordination with the P&ID to ensure that all operational requirements are met.

Control strategies should include a description of every process area on the P&IDs. At the very least, each P&ID should have an associated control strategy. The applicable control strategy should be identified and called out on the P&ID. Similarly the P&ID should be referenced in the control narrative’s referenced documents section.
6.5 Use of P&IDs during Final Design, Construction, Commissioning, and Testing

This section describes how P&IDs should be used during the Final Design, Construction, Commissioning, and Testing of a project.

6.5.1 Final Design

During the final design phase, P&IDs are the source documents for all other design information and design activities (data sheets, mechanical design, electrical design, instrumentation design, etc.). By their very nature, P&IDs must be continually reviewed and updated to reflect refinements in the design resulting from more detailed work by individual disciplines. As a minimum, however, P&IDs must be the first document reviewed and updated as the design moves toward an upcoming milestone (e.g., 30 percent, 60 percent, 90 percent, 100 percent completion points). For example, P&IDs produced during pre-design should be the first documents reviewed and marked up in developing the 30 percent design milestone.

In addition, the P&IDs will be one of the source documents, together with data sheets and control loop descriptions, upon which the instrumentation engineer will base the instrumentation design.

6.5.2 Construction

P&IDs will be produced for inclusion into the project manual as contract documents. This means that the District will rely on the P&IDs to require the Contractor to provide all features and functionality shown on the P&IDs, but not necessarily shown on other discipline drawings. A note to this effect should be added to the first P&ID symbol sheet. This approach may avoid some detailed discipline drawings, but it also requires that the P&IDs depict accurately and precisely the mechanical and instrumentation features of the project.

The Contractor is responsible for red-lining the P&IDs denoting any field changes, modifications, or updates during construction.

6.5.3 Commissioning and Testing

The Contractor’s red-lined P&IDs will be used as the roadmap for commissioning and testing as the plant is starting up. The startup engineer will be responsible for marking any field changes and marking off each functional area as the commissioning and testing are completed.

6.5.4 Post-Commissioning

After the commissioning period, the owner’s engineer will use the red-lined P&IDs to create a record set of drawings that reflect final conditions. The P&IDs will then be maintained as a schematic representation of the discrete functional areas of the plant. This will be used by operations and maintenance to understand the system, to troubleshoot issues, and to provide a “roadmap” for training.

6.6 Standard Legend, Symbols, and Abbreviations Sheet

The following pages have the District’s standard legend and abbreviations sheet. All designs should adhere to these standards.
Instrumentation and Controls Symbols and Nomenclature, Sheets S-00-I-0-01 – S-00-I-0-06 from SSSI are included below.
This page intentionally left blank.
Figure 6-1 Symbols and Identification Systems 1
Figure 6-3 Process Equipment, Valves, and Pipeline Symbols
Figure 6-4 Process Symbols and Conventions
Figure 6-5 Piping Systems and Equipment Prefixes
6.7 Sample Loop Diagram

The image below includes a sample Loop Diagram from another District project.
6.8 Installation Details

The following pages include sample installation details from another District project. Sheets S-00-I-5-01 – S-00-I-5-03 from SSSI are included below.

Figure 6-7 Installation Details 1
Figure 6-8 Installation Details 2
Figure 6-9 Installation Details 3
6.9 Control Network Block Diagrams

The following pages include sample control network block diagrams from another District project. Sheets S-00-ID-6-01, S-00-I-6-01 and S-00-I-6-02 from SSSI are included below.

Figure 6-10 Existing Control Network Block Diagram Demolition
Figure 6-11 Control Network Block Diagram 1
Figure 6-12 Control Network Block Diagram 2
6.10 Control Panel Layout

The following pages include sample control network block diagrams from another District project. Sheets S-00-I-6-03 – S-00-I-6-12 from SSSI are included below.

![Figure 6-13 Valve and Gate Control Panel Layouts](image-url)
Figure 6-14 Polymer Fill Station Layout and Elementary Diagram
GENERAL NOTES
1. PANEL MODIFICATIONS SHALL BE IN ACCORDANCE WITH NEC ARTICLE 554.4.A.B.
2. PROVISIONS OF THIS SPECIFICATION SHALL BE AS SPECIFIED UNDER DIVISION IV SPECIFICATIONS.
3. THE PANEL LAYS OUT SHELVING, COMPONENTS OF THE HARDWARE. THE CONTRACTOR IS RESPONSIBLE FOR THE MANUFACTURE, DESIGN.
4. FOR ALL PANELS CONTAINING MESSING NOT BE EXERCISED BY THE PANEL MANUFACTURER. CONGLOMERATE OF HEAVY GALVANIZED STEEL OR EXTRACTS IS ON THE FRONT OF THE PANEL, STANDING VARIOUS, TO PERSONNEL NOT BE EXERCISE BY MANUFACTURER OR DESIGNER.
5. PANEL MODIFICATIONS ARE AVAILABLE TO BE MADE TO THE PANEL AS PER THE REQUIREMENT OF THE CONTRACTOR.
6. PROVIDE WIRING DIAGRAMS OF THE PANEL ARE AVAILABLE UPON REQUEST.

KEY NOTES
1. PLC-SS-TOP
2. PLC-SS-MIDDLE
3. PLC-SS-BOTTOM

Figure 6-15 PLC-SN/SS Panel Modifications 1

Revision 4.1 – December 2019
Figure 6-16 PLC-SN/SS Panel Modifications 2
Figure 6-17 PLC-EA Panel Layout 1
Figure 6-18 PLC-EA Panel Layout 2
Figure 6-22 Blower Control Panel 4
6.11 P&ID Guideline/Mapping

The image below defines the expected general layout of the P&IDs. The symbols and graphics shown are for representation purposes and are not intended to be used on contract P&ID drawings.

Figure 6-23 Expected General Layout of the P&ID

<table>
<thead>
<tr>
<th>HMI</th>
<th>The displayed I/O and trending (optional) should be shown here.</th>
</tr>
</thead>
<tbody>
<tr>
<td>PLC</td>
<td>The I/O and any logic notes should be shown here. Relay interlocks should be shown here with detailed descriptions in the control strategies. PLC I/O points should be shown as filled in or hollow triangles.</td>
</tr>
</tbody>
</table>

GENERAL SHEET NOTES

Any notes that apply to this sheet in general should be listed here. Rearrange HMI and PLC entities to keep this from overlapping with any I/O points or logic notes.

Local Control Stations

Display local control panels and/or vendor control panels here.

Local / Vendor Control Panel

Motor Control Center

If client prefers, show MCC here. Works with minimal hand switches, indicators, etc. Relay logic wouldn’t work well here.

The field level equipment, instrumentation, and piping are shown on this level. The process engineer defines the piping, equipment, etc. The control engineer assists with the representation of the instruments.

Use correct wire line types.
6.12 Sample P&IDs

The following page includes a sample P&ID from another District project.

Figure 6-24  P&ID Sample
7.0 Control Panel Design

7.1 Introduction

The Control Panel Design Standard is intended to provide a design guideline for consistent and technically sound control panel layouts. The instrumentation and control system engineer will use the layout standard in conjunction with contract specifications 40 67 00, 40 67 33 and 40 67 63 to create a panel layout drawing for inclusion in the project Contract Documents. The panel layout drawing will provide the system integrator a reference for detailed panel design during the implementation phase of the project.

The Control Panel Design Standard, and the resulting panel layout drawing, is not intended to restate all the requirements already contained in the specifications or to be a standalone, detailed design document.

A sample panel layout is shown below in Figures 7-1 and 7-2 to illustrate the control panel layout requirements contained within the specification. The layout drawing is based on a two-door enclosure, but the concepts are scalable to larger or smaller enclosures based on the specific situation.

![Diagram of Control Panel Layout](image)

**Figure 7-1 Control Panel Layout: Front Enclosure View**
7.2 Control Panel Layout Requirements

At a minimum, the following requirements shall be incorporated in the panel layout drawing included in the Contract Documents. Those requirements that cannot be illustrated as part of the layout diagram should be included in the notes section of the drawing. The instrumentation and control system engineer may include other project specific notes that are deemed pertinent.

- Where permitted by location, enclosures housing PLCs shall be free-standing two door, full height enclosure with 3-point latch.
- Every control panel with a PLC is required to have an OIT installed. Reference specification 40 62 63 for OIT requirements. Ensure all OITs are properly grounded in accordance with manufacturer’s recommendations.
- The PLC chassis shall be located on the top right of the subpanel.
  - The typical layout for modules within a PLC chassis, RIO chassis or DIN rail mounted shall be placed in the following order from left to right. Some modules may not apply.
    - Power supply,
    - Processor module,
    - Communication modules (with Ethernet modules first followed by other communication modules),
    - Space (an empty slot with a filler plate),
    - AI module(s),
    - Space(s),
    - AO module(s),
    - Space(s),
    - DI modules,
- Space(s),
- DO modules,
- Space(s).
  - Group signals for the same piece of equipment together on the same I/O module.
  - Leave spare I/O on a module for future additions of I/O for that equipment.
  - Place AOs and DOs for redundant pieces of equipment on separate modules.
- The 19” rack mount assembly shall be located on the top left of the subpanel. The following equipment shall be included in the 19” rack assembly, listed in order from top to bottom:
  - Uninterruptible power supply (UPS)
  - Extended battery module for UPS
  - UPS maintenance bypass switch
  - Automatic transfer switch
  - Ethernet switch
- Whenever possible, AC and DC components, terminals and wiring shall be segregated.
  - In general, AC components and terminals shall be mounted on the left side of the subpanel. DC components and terminals shall be mounted on the right side of the subpanel.
  - AC wiring shall be in gray wire duct, DC wiring shall be in white wire duct.
- Each wire duct shall be allocated for field or panel wiring.
- Reference specification 40 67 33 for wire color scheme.
- The minimum depth for a control panel with a UPS rack mount assembly shall be 30”.
- Conduit entry shall be made in bottom of control panels. Side entry shall be permitted only when bottom entry is not possible. Conduit entry from top of panel is forbidden; new designs shall not call for top entry. If top entry of conduit into a control panel is desired in the field, a deviation request must be approved prior to doing so.
- Control panel shall be in accordance with NEC Article 409 & UL508A and UL698A, where required by area or panel classification.
  - Reference NEORSD Electrical Standards and Conventions Manual for additional requirements.
  - The panel layout example in Figure 7-2 depicts the general arrangement of the hardware installation zones. The contractor is responsible for the detailed panel design.
- Clearance between Intrinsically Safe and Non- Intrinsically Safe Circuits terminals shall be per UL 698A. Where space allows, a separate Intrinsically Safe Barrier (ISB) control panel shall be utilized. Sample panel layout is shown below in Figures 7-3 and 7-4.
**Figure 7-3 ISB Control Panel Layout: Front Enclosure View**

**Figure 7-4 ISB Control Panel Layout: Subpanel View**

**CONNECT POWER**

The terminals have a 24-V DC non-isolated power supply at these power ratings:
- 24V DC nominal (18...30V DC)
- 35 W maximum (1.46A at 24V DC)

**ATTENTION:** The power supply is internally protected against reverse polarity. Connecting DC+ or DC- to the earth ground terminal can damage the terminal. Connecting AC power, or more than 30V DC, can also damage the terminal.

The terminals support operation from a safety extra low voltage (SELV) or protective extra-low voltage (PELV) 24 V DC power supply. Supported power supplies include catalog numbers 1606-XLP95E, 1606-XLP100E, and 2711P-RSACDIN.

**ATTENTION:** Use a SELV or PELV supply as required by local wiring codes for your installation. The SELV and PELV power sources provide protection so that under normal and single fault conditions, the voltage between conductors and earth ground does not exceed a safe value.
To power the terminal from the same power source as other equipment, use a DC power bus.

To connect the operator terminal to a DC power source, follow these steps.

1. Verify that the wiring is not connected to a power source.
2. Strip 7 mm (0.28 in.) of insulation from your power supply wires.
3. Secure the DC power wires to the marked terminals (+ and -) on the terminal block.
4. Secure the earth ground wire to the GND terminal on the terminal block.

The GND terminal must be connected to a low-impedance earth ground.

**ATTENTION:** The earth ground connection to ground is mandatory. This connection is required for noise immunity, reliability, and Electromagnetic Compliance (EMC) with the European Union (EU) EMC Directive for CE marking conformance. This connection is required for safety by Underwriters Laboratory (UL).

In summary, the purpose of the Control Panel Layout Standard is to provide a resource that the instrument and control system engineer can use as a basis of design for the panel layout drawing(s) included in the Contract Documents. The Control Panel Layout Standard ultimately ensures uniformity between control panels throughout the project and across multiple projects.

### 7.3 Maximum Allowable Voltage

No voltage level higher than 120 volts shall be allowed within the control panel.

### 7.4 Control Panel Identification Nameplate Legend Convention

All Control Panels will have a nameplate that consist of three specific lines of text. The labeling convention is as follows:

- **Line 1** = PANEL TAG (see below)
- **Line 2** = PANEL NAME (E.g. Chemical Storage & Feed Control Panel)
- **Line 3** = SUPPLY POWER (E.g. Fed From Panel XX, Circuit YY)
Line 1 Panel Tag is created using the following formula:

[Location]-[Type]-[Process]-[Redundant Equipment]

Note: The separator between parts of a control panel nameplate are dashes. Separators for the asset tag name are underscores.


[Type]= Examples are listed below. See “Equipment Tag Naming Standard” for current abbreviations.

- PLC= Programmable Logic Controller
- LCP= Local Control Panel
- LCS= Local Control Station
- LAS= Local Alarm Station
- GAS= Gas Alarm Station
- ISB= Intrinsically Safe Barrier Panel
- NP= Network Panel
- FOPP= Fiber Optic Patch Panel
- PP= Patch Panel
- CP= Control Panel
- CRT= Cellular Router
- MCC= Motor Control Center
- OIT= Operator Interface Terminal (PanelView)
- PAC= Process Automation Controller
- RIO= Remote Input/Output Panel
- RTU= Remote Terminal Unit
- UPS= Uninterruptible Power Supply
- VCP= Vendor Control Panel
- VFD= Variable Frequency Drive

[Process]= 1 character to 3-character process code from “Equipment Tag Naming Standard” link* on the Consultant Contractor Resource Page on the NEORSD SharePoint site for Location, Area, and Process abbreviations. In some situations the equipment abbreviation can be used to substitute the “process” portion of the tag. For example, a PLC dedicated to a blower will have the blower name/abbreviation which then becomes part of the tag name. (*The link takes you to the Asset Tag Abbreviations File spreadsheet.)

Examples: W30-PLC-FE (Stand Alone PLC Panel in the screenings area of the Westerly WWTP, Ferric), S48-LCP-SK

[Redundant/Parallel Equipment]= Unique letter applied to end of label. (Begin first panel at 'A').
Example: E05-PLC-SCR-A (Parallel and/or redundant PLC equipment in the screenings area at the Easterly WWTP)

**Important note:** The area number portion of the location code (for example, the “20” in the location code W20) always represents the physical location of the equipment, control panel, device, or instrument (henceforth referred to as equipment). So, the area code does not always correspond to the area(s) served by the equipment.

# 8.0 Patch Panel Design

## 8.1 Patch Panel Requirements

At a minimum, the following requirements shall be incorporated in the patch panel design. The instrumentation and control system engineer may include other project specific notes that are deemed pertinent.

- All fiber optic patch panels shall be wall mounted enclosures. Fiber optic patch panels shall be EIA standard 19-inch width rack mounted enclosures.
- Provide fiber optic cable patch panels which meet the following requirements:
  
  1. Furnish panels with the following accessories:
     - Splice trays
     - Cable strain relief
     - Bend radius protectors
     - Routing guides
     - Grommeted cable entries
     - SD simplex adapters and adapter plates
     - Sufficient working space for removal of connectors
     - Identification label
     - Cable management hardware.
  
  2. Furnish each cabinet with a key lock and two (2) keys. All cabinets provided are to be keyed alike so that a single key opens all cabinets.
  
  3. Type: 316 stainless steel, 14-gauge enclosure, rated NEMA 4X in process or outdoor areas or NEMA 12 in control/electrical rooms. Solid center post with heavy stiffener. Stainless steel captivated door screws, oil resistant gasket with two 12 gauge steel panels mounted on collar studs.
     - Minimum size shall be 24” width, 24” high, and 12” deep.
9.0 Network/Server Rack

9.1 Introduction
The Network/Server Rack Standard is intended to provide a design guideline for consistent Network/Server panel layouts. The panel layout drawing will provide the system integrator a reference for detailed panel design during the implementation phase of the project.

The Network/Server Rack Standard, and the resulting panel layout drawing, is not intended to restate all the requirements already contained in the specifications or to be a standalone, detailed design document.

A sample panel layout is shown below in Figure 9-1 to illustrate the Network/Server panel layout requirements contained within the specification.

![Network Panel Layout](image)

Figure 9-9-1 Network Panel Layout

9.2 Network/Server Rack Requirements
At a minimum, the following requirements shall be incorporated in the rack panel layout drawing included in the Contract Documents. Those requirements that cannot be illustrated as part of the layout diagram should be included in the notes section of the drawing. The instrumentation and control system engineer may include other project specific notes that are deemed pertinent.

- The cabinets shall have the following features:
  1. Provide all electrical components and devices, support hardware, fasteners, interconnecting wiring required to make the cabinet complete and operational units.
  2. Locate and install all devices and components so that connections can be easily made and so that there is ample room for servicing each item.
3. Adequately support components mounted within the cabinet to prevent any movement.
4. Cabinets shall be NEMA 12 rated for control room locations.
5. Provide all holes and cutouts for installation of conduit and equipment. Top and bottom entry only.
6. Provide automatically controlled closed loop ventilation fans to maintain temperature.
7. Provide cable management for all power and communications cables. Use of wire ties, Velcro strap, tape and other non-mounted management is unacceptable.
8. Provide power distribution units at front and back rails of cabinet with minimum 25% spare capacity on each unit.
9. Ensure that all Ethernet switches, routers, and other rack mounted electronic devices are grounded in accordance with manufacturer’s recommendations.

10.0 Security

10.1 Introduction
The District PCS system consists of numerous highly integrated hardware and software components, and therefore PCS is a critical asset necessary for processing of wastewater. Due to PCS critically to operations, this section contains specific security requirements and policies to be incorporated in design. Software application security is handled in the application specific volumes of this manual.

10.2 Physical Security

10.2.1 Network Cabinets and Components
This section contains requirements for Network cabinets and components including but not limited to server cabinets, network components in control enclosures, fiber optic patch panels, and workstations.

- Network Cabinets
  - All cabinets shall be provided and assembled such that doors are installed and able to close.
  - All cabinets shall be provided with door locks. District shall rekey the locks after commissioning is complete to provide common key for all network enclosures and a separate common key for all fiber patch panels.

- Network Components [e.g., Cisco network switches.]
  - All rack mounted components shall be installed utilizing security screws. Security screws to be star-post mount style. Provide one security screw tool per cabinet.
  - All unused ports on components installed in any location other than a physically secured network room shall be physically secured. All port locks shall be black except for the port reserved for authorized programmers which shall be blue. Port locks prevent an unauthorized person from plugging a cable and device into an unused port. Acceptable port locks are shown below. Panduit refers to port locks as “jack block-out devices”:
    - Cat 5/6 RJ45 Ports – Panduit. Model: PSL-DCJB-BL (black)
- Cat 5/6 RJ45 Ports – Panduit. Model: PSL-DCJB-BU (blue)

![Figure 10-10-1 Cat 5/6 RJ45 Port Locks](image1)

- All patch cables installed as a drop to a network cabinet shall be a Cat 6, 24 AWG patch cord, Panduit catalog number NK6PC#BUY (or approved equal) where “#” is the placeholder for the length in feet. All patch cables installed entirely within a network cabinet shall be a Cat 6, 28 AWG patch cord, Panduit catalog number UTP28SP#BU (or approved equal) where # is the placeholder for the length in feet. Cables shall be blue unless otherwise specified.
- Cable plug boots that interfere with the installation of cable locks, specified below, shall not be used.
- All installed Category 5/6 cables shall be installed with a cable lock. Cable locks prevent an installed cable from being removed by an unauthorized person. Acceptable cable lock is shown below. Panduit refers to cable locks as “plug lock-in devices”:

  - Panduit. Model: PSL-DCPLX-BL (black)

![Figure 10-10-2 Cat 5/6 Cable Lock](image2)

### 10.2.2 Control Panels and Components

This section contains requirements for PCS panels including but not limited to: PLC Control Panels, Remote I/O (RIO) Panels, and other panels that contain any logic processing or I/O component.

- All panels shall be lockable. District Process Control and Automation (PC&A) to re-key to common key per site after commissioning has been completed.
• All doors on cabinets shall be installed with a door switch. The door switch shall energize cabinet lighting when any door is opened and de-energize lighting when the door is closed. Door switch shall also be wired to an input on an Environment Monitoring System (EMS), specified below.

• Environment Monitoring System (EMS) shall be model Poseidon2 3468 from HW Group. In addition to the input for the door switch(es), there are three more inputs that may be used in the future for a cabinet high temperature switch or other uses.

• Poseidon2 3468 EMS shall be powered from an NEC class 2, 24 VDC power supply. Allen-Bradley catalog number 1606-XLP50E, no equal.

• Poseidon2 3468 shall provide SNMP interface for integration with the District’s Zabbix web-based monitoring software.

• All Ethernet switches (e.g., Stratix 8000 series) shall be installed with port and cable locks, specified above. Blue shall be used for the programmer’s port lock; black for all other port locks.

• All patch cables installed as a drop to a control panel or PLC panel shall be a Cat 6, 24 AWG patch cord, Panduit catalog number NK6PC#BUY (or approved equal) where “#” is the placeholder for the length in feet. All patch cables installed entirely within a control panel or PLC panel shall be a Cat 6, 28 AWG patch cord, Panduit catalog number UTP28SP#BU (or approved equal) where # is the placeholder for the length in feet. Cables shall be blue unless otherwise specified.

• Cable plug boots that interfere with the installation of cable locks, specified above, shall not be used.

10.3 Virtual Security

• This section contains virtual security requirements for all network components. This is in addition to specific configuration requirements for integration into PCS networks covered in other sections.

• All unused ports shall be disabled by software configuration.

• All default user names and passwords for configuration shall be disabled or modified. Person(s) responsible for component configuration shall schedule work session with PC&A representative. During this work session, PC&A will provide the desired user names and password for the specific component.

• No component shall be installed without completing testing in Validation Center test bed. Reference Volume 1 for requirements.

• No component shall be installed in live production environment without ALL security requirements and configurations completed.

• During commissioning, a test port may be configured for use. This port shall be configured for MAC authentication to a specific programming laptop.

• All workstations and servers shall be managed by District policy. Policy settings include all spare ports to be disabled.
• User names, passwords, configuration files and other specific security information that could be used with malicious intent shall NOT be transmitted via email or other non-secured communications method.

10.4 Access Policies
All rooms and panels are secured by policy. Access to rooms and panels are restricted to PC&A, IT and maintenance staff only. All district contracted personnel which require access to these systems must have an approved Management of Change Form before any access will be granted.

11.0 Network Architecture
Section will be updated once APM Projects LT-17/17a have reached 30% design milestone.

12.0 Alarm Management

12.1 Purpose and Use of the Alarm Management Policy
12.1.1 General
One of the most critical functions of any control system is the ability to generate and display process and system alarms. This policy document addresses alarm system configuration and provides the necessary details for identifying, displaying and responding to process alarms as well as PCS, power, component and communication alarms. It is important to note that although OIT and HMI system functions can be used to monitor and generate alarms, in the Northeast Ohio Regional Sewer District’s (District) PCS process, alarms will be generated in the PLCs which will be logged and displayed on the HMIs and OITs. HMI application shall not be configured to perform alarm calculations. HMI generated alarms will be utilized only for alarms and events initiated from within the HMI software such as software status alarms, loss of communications with a PLC and other system level alarming.

Where necessary, alarm limits must be adjustable through the HMI graphics screens; however, those alarm limits will be used by the PLC in determining if there is an alarm condition. The nature of the distributed PCS is such that the PLC-based process control logic can and will continue to operate, even if one or more HMIs become unavailable. As a result, the PLC must be able to determine alarm conditions and act accordingly without the need for continuous communication with the HMI system.

Events are similar to alarms because both trigger storage of time-tagged information into a database. Events are dissimilar from alarms because events do NOT require corrective operator interaction. This policy addresses how to properly configure events in the alarm database. Both alarms and events are accessible by operators, but primary displays are configured to allow operators to focus on alarms which require corrective action. Where appropriate this document specifically addresses recommendations for event handling separately from alarm handling.
This Alarm Management Policy document is intended for use by the District’s contractors and in-house staff to ensure proper identification, development and application of alarms, maintenance of the alarm database, and effective overall alarm system functionality. Application of this policy is required to standardize alarms across all District facilities and ensure that the PCS alarm system always serves as a tool to effectively help the operator take the correct actions at the correct time.

This Alarm Management Policy defines the processes to ensure that:

- Alarms are properly identified and implemented
- Events and system messages are properly segregated from alarms
- Alarms are presented at a rate that an operator can effectively digest and manage
- Alarm descriptions are relevant, clear, and easy to understand so operators can decipher and respond to alarm information during high frequency alarm actuation events
- Alarms are configured consistently in accordance with industry best practice guidelines
- Operators can rapidly assess the location and relative importance of each process alarm
- The alarm database and alarm functions are properly managed as the district’s pcs and process facilities expand and change.
- Alarms are time-tagged and recorded in the PCS for review, assessment and long-term archiving.

Alarms shall be uniformly configured across all facilities such that operators that may move from one location to another can instantly recognize an alarm condition and its severity, state (acknowledged/unacknowledged), whether it is suppressed, and its associated process parameters. The graphical and audible notifications, means of acknowledgement, colors, modes, sizes in relation to process graphics, text, alarm lists, and all common functionality should be uniform throughout the control system to the greatest degree possible, and not site-specific.

Third-party HMI products packaged with vendor-supplied equipment should retain the vendor’s original programming provided that the system passes District safety standards. However, alarms that are communicated from packaged equipment to the PCS shall be subject to the requirements of the Alarm Management Policy.

Note: Throughout this document the terms alarm limits and operating limits may be used. The term “setpoint”, although sometimes used in other documents to describe an alarm setting, is reserved herein to mean the operator-entered or control logic determined desired operating value for a control loop.

- **Alarm limits** are settings at which alarms may be triggered. Alarm limits may be set from the HMI by users with proper security privileges. Alarm limit values are passed to the PLC and used in the alarm logic. An alarm status is set if the process value is sustained at or beyond the alarm limit for a preset time delay and meets other criteria assigned to the alarm.
- **Operating limits** are settings used to indicate to operators that the process is operating at the high or low end of the desirable range. Operating limits do not trigger alarms but should be recorded as events in the Wonderware event log.

### 12.1.2 Application

The Alarm Management Policy document shall be considered the controlling design guidelines for alarm selection and implementation in developing new systems and for effecting modifications to existing systems. It is required for both in-house use and for contractor/integrator use during projects.

This Alarm Management Policy document provides a consistent and optimum basis for:

- Alarm selection.
- Priority determination.
- Alarm configuration.
- Alarm handling methods.
- Alarm system performance monitoring.
- Nuisance alarm resolution.
- Alarm detection, presentation, and annunciation.
- Operator interface for alarms.
- Operator response to alarms.
- Alarm system change management.

The Alarm Management Policy is based on some key assumptions:

- Effective alarm management augments, but does not replace, constant surveillance by qualified operators.
- Operators are trained on, and understand, the alarm management policy.
- Alarm management enhances the operator's ability to make informed judgments based on experience and skill.
- Operators will respond to all alarms, regardless of priority.
- Alarm priorities define the order and urgency of the operator’s response.
- Alarms that indicate conditions that could be harmful to personnel health and safety will be classified at the highest priority level.
- The alarm system is routinely maintained and kept up to date.
- Alarm management includes all categories of alarms coming to an operator, including system alarms.

### 12.2 Alarm Definition and Selection Criteria

ANSI/ISA-TR18.2-2016 defines an alarm as “audible and/or visible means of indicating to the operator an equipment malfunction, process deviation, or abnormal condition requiring a timely response.” This is the basic definition that the District applies in determining whether a condition of a PCS database point or a system message should be classified as an alarm. It is essential to limit alarms to only those conditions that require an operator to take action that will correct an abnormal process condition, protect personnel and equipment, prevent violations of
regulatory permits, inform others of failures and hazards, mobilize maintenance personnel, and so on. The approach for classifying the criticality of each identified alarm condition is discussed later in this document.

The decision to configure an alarm for a process condition must be supported by positive responses to the following criteria:

- Does the condition require corrective operator action?
- Is the condition the result of an abnormal situation?
- Will the alarm aid in leading an operator to identification of the situation’s root cause?

Any process condition not meeting the criteria above, but that may aid in troubleshooting, is required to be and categorized as an event and logged. In cases of alarm occurrences that require in-depth analysis, the information in the event log is useful in analyzing the sequence of events, control actions and other transitions that may have contributed to an alarm situation.

District alarm selection and prioritization criterion are located in Section 12.7.4 through 12.7.7 of this policy.

12.3 Alarm States and Transitions

Each alarm point can exist in one of several states in the Wonderware system. The state of a point in the alarm database is an indication of its current status including both:

- In an alarm state or not
- Acknowledged by an operator or not

The alarm state is not directly indicative of criticality or priority. All alarm occurrences, regardless of priority or criticality must be recorded in the alarm log on the historian.

The PCS alarm configuration must comply with the following common states for alarm points as identified by ISA-TR18.2-2016:

- Normal (Not in an alarm condition)
- Unacknowledged (actively in alarm but not yet responded to by an operator)
- Acknowledged (actively in an alarm state but acknowledged via an HMI by an operator)
- Returned-to-Normal (transitioned from having been actively in alarm to normal state)
- Latched (held in an alarm state until reset by an operator or restored to normal by interlocks in control logic).

Also, the additional states of “Shelved”, “Suppressed by Design”, “Out of Service” and “Commissioning” must be used to describe the status of alarms that have been intentionally deactivated for various reasons. These have the following specific meanings:

- **“Shelved”** refers to an alarm that is temporarily suppressed, usually via a manual HMI action by the operator, using a method meeting a variety of administrative requirements to ensure the shelved status is obvious to all operators, and is tracked so it can be repaired (if needed) and returned to an active status.
• “Suppressed by Design” describes an alarm that has been intentionally suppressed due to a designed condition. This is a generic description that includes such items as simple logic-based alarms and advanced state-based alarming techniques. This type of suppression should be a normal programming approach for all District process control logic development, and should be described in the final Process Control Descriptions submitted following in-house or contracted process control programming activities. Examples are:
  o Suppression of a pump low discharge pressure alarm for a pump that is commanded to shut down
  o Suppression of a pump low suction pressure alarm for a pump that has just been started and therefore could not have yet primed.

The control logic should suppress alarms that are irrelevant due to process conditions, and reactivate the alarms only when process changes reinstate the relevance. In some cases the designed suppression should be for a preset time that is characteristic of the process, such as the time for a valve to fully open or time for a pump to prime and build discharge pressure after a pump is started.

• “Out of Service” refers to a non-functioning alarm, usually made inactive for reasons associated with the Maintenance stage of the equipment life cycle. An “Out of Service” alarm must also be tracked under alarm system administrative requirements, similar to a shelved alarm.

• “Commissioning” applies to alarms that have been suppressed either by being included in an alarm group that has been deactivated or by being individually suppressed by a contractor/integrator that is installing, testing and commissioning new or modified portions of the PCS as part of a project. As installation and testing are underway, and adjustments are being made to alarm limits and PCS components, process and system alarms originating in the new work must be rerouted or suppressed to prevent them from being a distraction to live operations.

The terms “deactivate”, “suppress” and “alarm suppression” are intentionally generic, and not specific to terminology used by a particular control system brand or product line. The terms are used to indicate when the alarm functionality is not active (generally through a manually selected or PLC control logic-based override mechanism).

It is possible to suppress an alarm through actions that do not conform to proper work practices, and the detection of such undesirable situations are included in regularly conducted alarm system monitoring and maintenance. Changes can result from physical and programming work being performed by contractors. For example, alarms may be disconnected or disabled by a modification of PLC logic that intentionally or inadvertently bypasses a valid alarm check. Extreme alarm limits maybe set in a PLC during testing or other activities. During changes to HMI displays an alarm indication may be lost if the modifications are not fully tested. If not tracked and restored these may result in important alarms being disabled or hidden from an operator.
12.4 Alarm Annunciation and Response

The diagram below is the ISA18.2 feedback model of operator process interaction in response to an alarm condition:

![ISA18.2 Alarm feedback model](image)

**Figure 12-1 ISA18.2 Alarm feedback model**

In some cases an experienced operator may recognize the need to refer an alarm condition to a maintenance crew to troubleshoot and remediate a mechanical, electrical, programming or other type of fault that can’t be corrected by normal operational procedures. This is particularly true for alarms resulting from faulty equipment or process control instability. In such a case the path of the model would branch to the maintenance resources until the faulty component could be restored to good working condition or the instability resolved.

### 12.4.1 Operator Roles and Responsibilities for Alarms

This section contains the expected actions of operators in regard to alarm acknowledgement and response.

*Alarms should not be left unacknowledged. Operators shall address alarms as soon as possible after they appear in a first in-first acknowledged order. However, it is up to the operator to recognize various levels of alarm criticalities among incoming alarms and take the proper steps to address high criticality alarms ahead of less critical alarms if the situation demands such action.*

*Acknowledgement of alarm requires Operator to enter descriptive comments on HMI regarding alarm root cause and resolution. Work ticket number should be entered if required for resolution. Comments will be historized and available for query. Comments will be periodically reviewed to address common alarm issues and assist with maintenance of the alarm system.*

Table 12-1 depicts the allowable actions for various system log-in levels assigned to District personnel:
### Table 12-1 Wonderware login allowable alarm actions

<table>
<thead>
<tr>
<th>Operator Level</th>
<th>Alarm Acknowledge</th>
<th>Alarm Suppress</th>
<th>Alarm Limit Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Default – View Only</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>18 Operators</td>
<td>YES</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>2798 Operators</td>
<td>YES</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>Facility/Process Area Managers</td>
<td>YES</td>
<td>YES</td>
<td>YES*</td>
</tr>
<tr>
<td>Programmers</td>
<td>YES</td>
<td>YES</td>
<td>YES**</td>
</tr>
<tr>
<td>Administrators</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
</tbody>
</table>

* Operation and Maintenance Supervisory and Management level personnel may change alarm limits where PLC control logic allows. See specific process area’s Process Control Description.

** Requires approved change request – approval by PCS Manager.

### 12.4.2 Consideration for Alarms Routed to Multiple HMI Locations

Many alarms may occur on a large process control system over the course of a day, or even within very short time spans, if unforeseen upsets occur. Incoming alarms associated with large-scale process upsets and system faults can overwhelm operators, so it is important to not present operators with more alarm information than they need for their area-specific strategic decision-making. Each operator needs the information that will protect the people, equipment and process integrity in their area of responsibility, as well as some facility-wide information needed to have an overall understanding of the facility’s operating status.

Alarm filtering and routing should be applied by workstation location to avoid alarm notifications that don’t apply in any way to the local facility or process area. Some global alarms will need to be present on all HMI displays across a plant, from plant-to-plant, or between plants and collection system sites. However, potential inter-facility alarms should be scrutinized to determine if they are truly needed at a particular HMI location, or if they should only be indicated at main control centers or to management level log-ins.

Alarm displays and notifications may be filtered by log-in, workstation location and facility, as appropriate, to minimize irrelevant alarm notifications and alarm banner overloading, and to improve operator response time by reducing distractions. An example, shown below in Figure 12.2, is the filtering that has been applied at the Southerly Wastewater Treatment Center (SWWTC) based on distinct trade union process operation assignments and associated workstation locations. This allows operators to focus on their areas of responsibilities by removing information that is not useful from their HMIs. The District’s three plants and the collection system each have unique processes, staffing, HMI distribution, and operational procedures, so the filtering and routing of alarms should be customized to each facility, HMI location and log-in level. However, customization shall not include any deviations from HMI standards, including alarm depictions on the graphics and alarm banner.
All alarm routing, grouping and filtering must be documented and available for review and sorting in tag database listings and in HMI system configuration files. Alarm routing review should be included in periodic alarm configuration audits.

12.4.3 Alarm Summary Display Characteristics and Usage

12.4.3.1 FACILITY-WIDE OR PCS-WIDE ALARM SUMMARY DISPLAY
The alarm summary graphic is configured to display alarms only and has filtering applied by plant.

Alarm summaries can be for active alarms or past alarms that are no longer active. The inactive alarms are stored in the alarm and event database in the historian and can be retrieved for viewing. Active alarms are displayed on the HMI alarm summary.

12.5 Alarm System Performance Auditing
Maintaining optimal alarm system performance requires continual monitoring and maintenance. This section defines the roles and responsibilities for alarm system monitoring and maintenance, and the District’s key performance indicators (KPIs).

The alarm system must undergo scheduled periodic audit by knowledgeable personnel from technical and operations departments. The alarm audit will include statistical review of alarm occurrences as well as confirm alarm configurations and settings against the approved alarm management database and supporting rationalization documentation. If system is found outside of the guidelines included in this section, the system should be considered non-compliant and work packages will be generated to restore the system to optimal performance levels.

The alarm management system should be optimized to present an operator at an HMI with no more than 10 alarms per hour or 150 alarms per day. The maximum allowable alarms for a 30-day period are no greater than 12 alarms per hour (average) or 300 alarms per day. If a 30-day audit results in alarm count in excess of recommendations, a root cause analysis will be performed. This analysis will include generation of a Pareto to identify alarms with the greatest frequencies and detailed analysis of these alarms against the approved definition and
rationalization standards. Specific alarms may need to be re-rationalized including limit reviews if it is determined that the alarms are occurring within normal process condition boundaries.

Safety is always a key consideration when designing process controls and instrumentation. A reduction in personnel injuries and equipment safety incidents are key KPIs. While difficult to correlate, reduced incidents can sometimes be attributed to improvements in alarm management practices.

Proper implementation of the alarm system management process has the following direct benefits:

- Effective process management by operators.
- Predictable operator actions in response to abnormal situations.
- A systematic approach to resolving process problems.
- Improved process uptime due to fast and efficient alarm response.
- Awareness of alarm needs and functionality by process engineers during facility design.

The alarm audit process should involve operators so they gain confidence in the value and integrity of the process alarms, and continue to use the system to its greatest capabilities.

The alarm audit will be conducted by District Process Control and Automation (PC&A) group on a quarterly basis.

12.5.1 Importance of audit

Alarm system auditing can help identify outdated or inappropriate alarm settings, abandoned alarm system tags and needed additions to the alarm tag database. Auditing followed by alarm system maintenance can improve alarm rates and reduce overloading.

ISA-TR18.2.5-2016 focuses on the audit requirements to ensure the established system is reviewed and improved where needed. Along with auditing the alarm database, logs, displays, and operator recognition and response times, periodic auditing will help keep the alarm management work processes aligned with staffing resources and a reasonable audit frequency.

Alarm management practices as per standards and best practices have been treated as “recognized and generally accepted good engineering practices” in US Occupational Safety and Health Administration guidelines. Hence the absence of such practices could be seen as a shortcoming, particularly in hazardous chemicals and transporting material in pipelines, if an industry wants to improve the safe operation of plants and other entities.

Auditing alarm management practices also tells operating companies the status of a control system to ensure safe and reliable processes. The audit is also done for compliance to international standards and best practices and internal procedures. Organizations use audit results to develop and improve the alarm system and the performance of the personnel working with the alarm system to meet the objectives of the Alarm Management Strategy.
12.5.2 Audit approach

The audit approach addresses both alarm performance and improvement. In general the audit program covers the following areas in alignment with the PC&A Department’s PDCA life cycle approach. The PDCA approach includes:

**Plan**
- Select the plant, process area or sub-process area to include in the audit.
- Identify audit team including PC&A, appropriate Unit Process Managers and Operators.
- Align with published standards and the KPIs included herein.
- Focus on developing tabulations of clearly needed additions, deletions, revisions and opportunities for improvement. Set a goal level for each KPI.

**Do**
- Using the Wonderware Alarm Advisor Dashboards, complete the data collection for the defined period and alarm areas.
- If the audit results show similar widespread types of problems, revisit the procedure; for example, the change management process may have to be modified if it is not enforced or if it is not practical to follow some of the recommendations.

**Check**
- Compare the goal levels of each KPI against actual alarm data.
- Review alarm-related work orders and known issues that have occurred since the last audit. Involve operators to obtain clarification of reported issues. Involve Maintenance where possible instrumentation, mechanical or electrical changes are needed.

**Act**
- Do improvement activities. Involve and update operators during remedial activities so they see the audit process at work, collaborate in testing changes, and gain confidence in the alarm configurations.
  - Review alarm-related work orders and known issues that have occurred since the last audit. Involve operators to obtain clarification of reported issues. Involve Maintenance where possible instrumentation, mechanical or electrical changes are needed.
  - Review out of compliance alarms against the alarm management database for any unauthorized changes.
  - Complete definition and rationalization steps to mitigate nuisance alarms and update the master alarm database.
  - Implement the corrective actions
- Follow up by gathering objective evidence of process improvements.
- Demonstrate improvements in abnormal situation management.

12.5.3 Alarm System Monitoring Roles and Responsibilities

Alarm system auditing is included in the District’s PC&A Preventive Maintenance Program so it is scheduled and required to be executed on a regular basis. The manager of PC&A is responsible to initiate and assign resources to perform the audits annually on a per PLC basis as part of the preventative maintenance program.
Resources performing the audits should be knowledgeable about the current PCS alarm database, projects that are underway that may affect the HMI system, and the HMI system’s available alarm tracking and reporting tools.

12.5.4 Alarm System Key Performance Indicators and Analyses

Figure 12-3 contains a listing of the District’s alarm system KPIs.

<table>
<thead>
<tr>
<th>KEY PERFORMANCE INDICATORS</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Average overall process alarm rate &lt; 150/operator per day</td>
</tr>
<tr>
<td>• Percentage of time alarm rate exceeds acceptable target rate &lt; 15%</td>
</tr>
<tr>
<td>• Distribution of alarm priorities over the course of a week</td>
</tr>
<tr>
<td>o Critical (P1 Alarm Level = 1): &lt; 10%</td>
</tr>
<tr>
<td>o High (P2 Alarm Level = 2): 25-40%</td>
</tr>
<tr>
<td>o Low (P3 Alarm Level = 500): &gt; 50%</td>
</tr>
<tr>
<td>• Percentage of suppressed alarm tags (Goal=zero, not including those shelved for commissioning, flooding, or by control strategy)</td>
</tr>
<tr>
<td>• Number of chattering* alarms &gt;10 transitions per day, Goal=0</td>
</tr>
<tr>
<td>• Number of stale** alarms &gt;24 hrs. old, Goal: &lt; 25 per plant</td>
</tr>
<tr>
<td>• Alarm flooding*** occurrences per day (Incidents of &gt;100 alarms in 10 minute period). Goal: &lt; 5 per plant</td>
</tr>
<tr>
<td>• Number of unauthorized changes in alarm limits, priorities, active status, etc. (This does not include actions taken that adhere to standard operating procedures. Goal=0</td>
</tr>
<tr>
<td>• Number of occurrences of process control modes being changed per week (may indicate operator actions to inhibit recurring alarms that may be due to problems such as poor control loop tuning, invalid control logic, equipment problems, lack of analog input filtering, or incorrect alarm settings). Note: Baseline data should be collected during the first year of alarm system audits to assist the District in setting improvement goals.</td>
</tr>
</tbody>
</table>

Figure 12-3 Alarm system key performance indicators

* Chattering: On/Off Frequently
** Stale: Left in alarm state for extended periods
*** Flooding: Many related alarms at the same time

The audit includes a review of current conditions and review of recent alarm records, and results in a tabulation of the value observed for each KPI versus the goals for each KPI. The KPIs should be reviewed and revised annually to promote continued performance improvements.

The PC&A manager and operation and maintenance managers should review the compiled results after each audit and determine where to focus the most urgent analysis and corrective actions.
Figure 12-4 characterizes a large PCS in terms of its rate of incoming alarms against an acceptable average rate per Operator. As a system approaches the reactive and overloaded zones of this graph, an operator will be increasingly unable to fully assess each alarm and appropriately respond. Successful alarm management should help to maintain the maximum and average rates in the manageable zones. The maximum and average rates should multiplied by the number of minimum number of operators on-shift per facility.

![Figure 12-4 Acceptable alarm rates per operator](image_url)

The alarm system should be maintained within the predictive/robust/stable thresholds.

- Average alarm rate < 10 alarms / 10 minutes
- Maximum alarm rate < 1000 / 10 minutes
- AND alarm rate outside of average/maximum rates no greater than 25% of the sample period

### 12.5.5 Alarm Performance Reports

The District has deployed Wonderware Alarm Advisor to create alarm system KPI reports. The reports will be created and maintained by PC&A. There is one report configured per facility which includes the KPI fields located in Section 12.5.4 of this document. Additionally the follow data is available for review:

- Total number of alarms over 30-day period
- Average number of alarms per day
- Average number of alarms per hour (maximum number of alarms per hour)
- Average number of alarms per 10-minute period

Additionally, the system should be reviewed for chattering alarms, stale alarms and unauthorized changes.

Wonderware Alarm Advisor fields can be manipulated by the user to filter and sort data for the audit to be performed.
12.5.6 Alarm Record/History Retention
As with PCS data retention, alarm history record retention requirements are not defined in the District’s general Data Retention Policy as is the case for other departmental records. Alarm data should be retained for at least five years, or until any identified need for a specific set of data lapses. For example, if alarm data for a particular process is needed for engineering or planning purposes, it should be retained as long as necessary to complete the work.

12.6 Alarm Handling Methods

12.6.1 Nuisance Alarm Handling
All alarms that exist in the system shall have been established through the alarm definition and rationalization process. At times, conditions may exist where rationalized alarms transition into a nuisance alarm state due to a change within the system. Examples include: instrument failure, instrument out of calibration, maintenance or testing.

Prior to classifying an alarm as a nuisance alarm, the alarm should be reviewed against the definition and rationalization data in the alarm management database to ensure compliance with the approved alarm settings. If the alarm is configured as approved but the normal operating process conditions have changed, the alarm should be re-rationalized rather than suppressed.

In cases where the process change is temporary or the alarm condition is due to other abnormal situations, the alarm should be handled as a temporary nuisance alarm. To prevent operators from distractions caused by nuisance alarms, the Wonderware system is configured to allow for temporary alarm suppression utilizing alarm shelving. The cause of each nuisance alarm must be investigated and findings shall be recorded in the District’s Work and Asset Management (WAM) system. PC&A shall correct the problem or, if necessary, a work request shall be issued by PC&A or authorized operating personnel to other appropriate resources, depending on the type of problem causing the overactive alarm.

Alarms that must be suppressed for extended durations should be disabled at the HMI by PC&A through generation of a work request and approved management of change (MOC) request. Extended suppression shall require administrative approval and safety review. Alarms classified as Priority 1 shall not be suppressed via any method other than shelving.

12.6.2 Advanced Alarm Handling Methodologies
The District PLC & HMI standard define requirements for signal filtering, alarm delays, bad measurement alarms and associated logic blocks. These settings associated with each analog input database point help minimize alarms due to naturally occurring levels of signal noise and measurement instability. Filters and dead bands should be kept at the lowest practical values, but not lower than minimum standard settings.

For new installations, the recommended initial settings are shown in Table 12-2.

Table 12-2 Alarm filtering minimum settings

<table>
<thead>
<tr>
<th>Signal Type</th>
<th>Filter Time Constant</th>
<th>Dead band (% of range)</th>
<th>On-Delay</th>
<th>Off-Delay</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flow</td>
<td>2s</td>
<td>5%</td>
<td>5-15s</td>
<td>5-15s</td>
</tr>
</tbody>
</table>
All signal filtering, alarm delays, and bad measurement alarm settings shall be stored and kept up-to-date in the alarm management database.

12.6.3 Alarm Shelving
Alarm shelving allows operators to manually suppress specific alarms for temporary periods. It is a tool for assisting an operator to effectively respond during a plant upset by hiding less important alarms. The following rules apply:

A. Operator shall NOT be able to shelve safety critical alarms.

B. Authorized operators shall be able to shelve low and medium priority alarms without special approvals.

C. Operator shall log the reason for shelving any alarm.

D. Authorized operators shall be able to shelve alarms by group or on individual basis.

E. Operator shall have access (via HMI) to view and print the complete list and quantity of shelved alarms in any operational area.

F. Operators shall review the list of shelved alarms at each shift change, with special focus on newly shelved alarms and alarms restored to service since the operator’s last shift.

G. Shelving of alarms will be automatically logged to a historian event log.

H. Repeated and routine shelving of common alarms shall trigger rationalization review for corrective action.

I. Points shall be configured so if shelved they will automatically be restored to active status after a preset time period based on priority level:

<table>
<thead>
<tr>
<th>Alarm Priority Group</th>
<th>Maximum Shelving Time (Hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1</td>
<td>N/A</td>
</tr>
<tr>
<td>P2</td>
<td>8</td>
</tr>
<tr>
<td>P3</td>
<td>24</td>
</tr>
<tr>
<td>P4</td>
<td>N/A</td>
</tr>
</tbody>
</table>

The Operator Interface for suppression of alarms is contained in the DISTRICT’S PCS HMI Standards.
12.6.4 State-Based or State-Dependent Alarms
State-based alarming shall be incorporated to allow for temporary suppression of low-energy alarms on out of service equipment. High energy alarms must be retained; limits will be dynamically modified to activate alarms at lower threshold limits.

Low-energy alarms are defined as alarms for process conditions below optimal operation (e.g. low level, low discharge pressure).

High-energy alarms require an increase in the process variable due to energy transfer (e.g. high pressure, high tank level). High-energy alarms can typically be identified following standard Lock-out/Tag-out (LOTO) procedures for defining the energy source.

Example:
Table 12-4 Example state dependent alarms

<table>
<thead>
<tr>
<th>Chemical Tank ####</th>
<th>Normal Operation</th>
<th>Out of Service State</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Pressure SP</td>
<td>250 PSIG</td>
<td>5 PSIG</td>
</tr>
<tr>
<td>High Level SP</td>
<td>90%</td>
<td>2%</td>
</tr>
<tr>
<td>Low Level SP</td>
<td>5%</td>
<td>N/A – Suppressed</td>
</tr>
</tbody>
</table>

Process measurement alarms affected by motor operation should be interlocked in the PLC control logic with the motor run feedback. (e.g., pump low discharge pressure should be suppressed until pump is confirmed running).

State based interlocking details shall be described in the process control narrative that documents the PLC control logic, and in the alarm management database.

12.6.5 First-Out Logic for Alarm Flood Suppression
Use of a common alarm is required for all equipment that would otherwise generate numerous alarms upon abnormal shutdown. First-out logic and the HMI displays shall be configured to allow operators to view specific sequences of alarms and interlocks that have caused an abnormal shutdown. First-out logic blocks monitor a number of known process events that will cause a device to fail or trip. The logic block will trigger a common alarm when any of the events or combination of events occurs. Additionally, the logic block contains a sequence queue that will store the events in the order they occurred (first in, first out). The event queue will transfer the queue to PCS for display in device faceplate and as an event for logging. The use of first-out logic allows the operator to clearly see the device in alarm and the sequence of the events triggered to determine the root cause by identification of the first event.

Common alarms shall be described in the process control narrative and documented in the alarm management database including a listing of all possible events (first-out items). Each first-out shutdown trigger shall be logged as an event. A first-out logic block and first-out device faceplate is available in the Districts PCS HMI & PLC Standards.
12.6.6 Operator Messaging and Alert Systems
Primary operator notification of alarms is through use of the HMI alarm banner described in other sections of this document. In addition to the alarm banner, the HMI has been configured to display an overlay faceplate on all screens for Priority 1 alarms to ensure operator awareness. Additionally, Priority 1 alarms shall provide the operator audible cues. The District’s HMI standards and other PCS standards shall dictate the alarm display formats, means of notification, sounds associated with various alarms, escalation of notifications and other operator alert system settings.

12.7 Alarm Documentation and Rationalization
Alarm documentation and rationalization (D&R) is a sound, consistent, and logical methodology by which alarms are determined and prioritized. Alarms resulting from the methodology are said to be “rationalized”. Sections 12.7.1 through 12.7.7 step through the D&R process and include recommendations as guidelines to structure the process.

The District requires the complete alarm definition and rationalization process to be followed as part of all projects. Any change request impacting the alarm system shall be reviewed against the master alarm database, if the change impacts the rationalization parameters or alarm priority the change approval must include the unit process operator in addition to the manager of PC&A.

12.7.1 Pre-Programming Requirements
Prior to the pre-programming workshop, the application programmer shall develop the initial alarm priorities recommendations and submit for review.

The application programmer shall rationalize and define each alarm added to the system using the process in Sections 12.7.3 through 12.7.9. Application programmer shall complete an alarm management spreadsheet for new systems or update District existing spreadsheet for modifications and submit to District for review and approval. An example of the spreadsheet is located in Appendix B, the master file is located on District SharePoint.

Application programmer shall allocate a portion of the pre-programming workshop(s) to host District definition and rationalization team (reference Section 12.7.2 for team requirements) and re-complete steps 12.7.3 through 12.7.8 for alarms noted by District for additional review during submittal response.

After the pre-programming workshop, application programmer shall submit a record copy of the final master alarm spreadsheet. Note: the application programmer is responsible for removal of any deleted alarms from District master alarm spreadsheet.

12.7.2 Alarm Definition and Rationalization Team
Alarm D&R should be completed by a team consisting of knowledgeable staff members representing operations, engineering, safety and management. At a minimum, the following District staff shall review the submitted D&R and be in attendance for the pre-programming D&R review:
PC&A manager
Unit process managers
Engineering
District safety representative (for any project with life safety modifications)
Operations supervisors

12.7.3 Alarm Definition and Rationalization – Required Documents
To prepare for the definition and rationalization process, the following documents shall be made available to the team to the extent that they exist and are up to date:

- Alarm management database
- Alarm management strategy
- P&IDs
- HMI screens
- Process control descriptions (process control narratives, operation and maintenance manuals)

In the absence of updated P&IDs and process control descriptions, a field walk by a knowledgeable process controls engineer whom is participating in the definition and rationalization team is recommended.

12.7.4 Alarm Determination
The first step of the process is to determine whether or not the input meets the criteria to be an alarm.

Steps to be completed on each existing alarm and/or signal to be evaluated:

- Determine if the input is an alarm. It is an alarm if all three questions result in a positive response:
  - Does the condition or event require corrective operator action?
  - Is the condition or event the result of an abnormal situation?
  - Will the alarm aid in leading an operator to identification of the situation’s root cause?
- If it is determined an alarm, add the signal to the alarm management database and rationalize:
  - Determine alarm priority
  - Determine any state and transition conditions
  - Analyze and set alarm limits
- If it is not an alarm, follow District PCS Standards and Conventions Manual for configuration as an event.

Upon completion of the D&R process, each alarm shall be contained in the alarm management database including all fields and any special notes/considerations from the process.
12.7.5 Areas of Impact and Severity of Consequences

The second step of D&R is to review each alarm to determine the impact category and severity of consequence.

The District maintains a listing of critical equipment by site and process area in Appendix C. For signals which meet the alarm definition in Section 12.7.4 and are within one of the process areas in Appendix C, the steps contained in Sections 12.7.5 and 12.7.6 can be skipped and the alarm shall be entered into the Master Alarm Database as a Priority 1 alarm.

For alarms outside of the crucial process areas, using Table 12-5, review the impact categories and assign the alarm to the most applicable category. Next, determine the alarm’s severity based on the severity statements for the chosen category.

As an example, a chemical leak would have the classification of “Environmental”. The severity would be determined by the extent of the impact, the location of the sensor should be reviewed to determine if the leak is contained or uncontained. If contained, the severity would be Major and if uncontained the severity would be SEVERE. This is determined by review of the planned instrument placement.

Table 12-5 Areas of classification and severity

<table>
<thead>
<tr>
<th>Impact category</th>
<th>Severity: NONE</th>
<th>Severity: MINOR</th>
<th>Severity: MAJOR</th>
<th>Severity: SEVERE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Personnel safety</td>
<td>No injury or health effect</td>
<td>Any alarm for which operator is primary method by which harm is avoided, shall non-exclusively utilize Priority 1.</td>
<td>Effect within facility only.</td>
<td>Discharge permit violation.</td>
</tr>
<tr>
<td>Public or environment</td>
<td>No Effect</td>
<td>Warnings/pre-alarms</td>
<td>Effect within facility only.</td>
<td>Uncontained release.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Any contained release.</td>
<td>Alarm causing public notice.</td>
</tr>
<tr>
<td>Equipment</td>
<td>Warnings/Pre-alarms</td>
<td>Equipment with redundancy that shuts down</td>
<td>Equipment shutdown and needs a restart within 4 hours</td>
<td>Equipment critical to operations shutdown (eg.PEPS)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Any power conditioning alarms/warnings.</td>
<td>Any power loss and generator alarms.</td>
</tr>
<tr>
<td>Process control system (PCS)</td>
<td>N/A</td>
<td>Warnings and Minor Faults</td>
<td>PLC requiring maintenance that does not impact operations</td>
<td>PCS fault affecting operations or HMI connectivity.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Any network equipment alarms.</td>
</tr>
<tr>
<td>Security</td>
<td>N/A</td>
<td>Invalid Log-on attempt</td>
<td>In plant - door/hatch entry</td>
<td>Remote sites - door/hatch entry</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Fire Alarms</td>
</tr>
</tbody>
</table>

These ratings when combined with response time (Section 12.7.6) will determine the alarm priority.
12.7.6 Maximum Time for Response and Correction

The third step of D&R is to review each alarm to determine the maximum allowable time for operator response and correction.

Select the allowable maximum time to respond from Table 12-6 which avoids escalating potential for damage, injury, process effects, and other considerations. The evaluation must take into account remote, unstaffed locations requiring travel time and/or special access such as restricted properties.

Table 12-6 Maximum time for response and correction

<table>
<thead>
<tr>
<th>Alarm response urgency</th>
<th>Maximum time to respond</th>
</tr>
</thead>
<tbody>
<tr>
<td>When possible (before end of shift)</td>
<td>Greater than 30 minutes</td>
</tr>
<tr>
<td>Promptly</td>
<td>10 to 30 minutes</td>
</tr>
<tr>
<td>Rapidly</td>
<td>3 to 10 minutes</td>
</tr>
<tr>
<td>Immediately</td>
<td>Less than 3 minutes</td>
</tr>
</tbody>
</table>

For each alarm, utilize the defined response urgency and consequence classifications to determine the alarms priorities (P1-P3) in Table 12-7.

Example: a regulatory violation is classified in the areas of impact and consequence as SEVERE, and if the defined time to respond is rapidly; then the alarm will be Priority 2.

Table 12-7 Alarm prioritization matrix

<table>
<thead>
<tr>
<th>Maximum time to respond</th>
<th>Consequence severity: MINOR</th>
<th>Consequence severity: MAJOR</th>
<th>Consequence severity: SEVERE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Greater than 30 minutes</td>
<td>Revisit alarm rationalization to re-engineer for consistent characteristic of urgency</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10 to 30 minutes</td>
<td>P3</td>
<td>P3</td>
<td>P3</td>
</tr>
<tr>
<td>3 to 10 minutes</td>
<td>P3</td>
<td>P2</td>
<td>P2</td>
</tr>
<tr>
<td>Less than 3 minutes</td>
<td>P2</td>
<td>P1</td>
<td>P1</td>
</tr>
</tbody>
</table>

12.7.7 Wonderware Alarm Level Determination

The District utilizes the Wonderware standard alarm level divisions for prioritization. All non-alarm network, power, HMI and PLC system messages are included in the Priority 4 group. Application programmer shall utilize Table 12-8 to determine the appropriate Wonderware alarm level number based on the priority (P1-P4) documented in the alarm management database.

Table 12-8 Alarm priority to alarm level matrix

<table>
<thead>
<tr>
<th>Alarm priority group</th>
<th>Description</th>
<th>Wonderware alarm level</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1</td>
<td>Critical</td>
<td>1</td>
</tr>
<tr>
<td>P2</td>
<td>Medium</td>
<td>2</td>
</tr>
<tr>
<td>P3</td>
<td>Low</td>
<td>500</td>
</tr>
<tr>
<td>P4</td>
<td>Event</td>
<td>751</td>
</tr>
</tbody>
</table>
### 12.7.8 Alarm Limit Selection

Alarm limits shall cause alarms to occur only when there is a need to alert an operator to respond to abnormal conditions or events. Alarm limit settings shall be set to provide for adequate time for response before critical conditions are reached.

Alarm limit selection requires that the D&R team to review historical process data; alarms should be set outside of normal operating conditions. Statistical analysis methods can be used to compare alarm settings to process history; utilize historical data to determine the upper and lower control limits during normal operation to determine appropriate alarm limits.

Alarm limits must be consistent and cooperative with limitations from the following areas:

- Personnel safety
- Environmental protection
- Process design
- Plant dynamics
- Instrumentation
- Process history
- Equipment design

### 12.7.9 Alarm Documentation

A master alarm database shall be maintained. An example of the completed database is provided in Appendix B.

For each alarm the following information must be included and maintained up to date in the database:

- PCS tag
- Description
- Alarm limit(s)
- Conditioning requirements
  - Filtering
  - Time delay
  - Voting
  - State-based logic
  - etc.
- HMI graphic screen nos.
- Possible causes of alarm
- Operator response
- Required time to respond
- P&ID and loop diagram nos.
- Process control narrative no.
- Classification.
Process control narratives (PCN) shall be updated to reflect addition or deletion of alarms. PCN shall include the following, minimum, information:

- PCS tag
- Description
- State-based logic
- Process interlocks

### 12.7.10 Alarm Classification

The District utilizes alarm filtering for routing to the appropriate operator. To provide consistency in approach alarms shall be classified or grouped as defined in the District’s HMI standards.

### 12.7.11 Alarm System’s Relationship to Other Site Procedures

Alarm and event response requirements are integrated within the District’s policies and procedures.

The MOC procedure shall address changes to alarm management system including but not limited to alarm limits, alarm priority and suppression.

Additionally standard operating procedures for emergency response will include the applicable alarm tag that may be the root cause of the event. Responses for health and safety, environmental release and spill response have direct correlation to alarms within the PCS.

### 12.7.12 Alarm System Implementation, Commissioning, and Checkout

Alarm configurations may need to be validated as they are modified. The District’s standard requirements for use of the Rockwell and Wonderware validation test bed and normal control strategy checkout should occur to the extent practicable, as would be done under any integration contract or in-house work order.

During loop checks for new or replaced instrumentation, operations should observe and sign off on the proper system response to alarm occurrence, acknowledgement, and resetting.

### 12.8 Specific Alarm Design Consideration

Up-front decisions regarding alarm configuration will reduce time spent in rationalization. Decisions can usually be made in advance based on several factors:

- Sensor malfunction or similar bad value alarms (existence, priority, placement)
- Pre-alarms
- Duplicate alarms
- External device health and status alarms (emergency shutdown device, surge control, analyzer, etc.)

#### 12.8.1 Handling of Alarms from Instrument Malfunctions

Analog AOI blocks are configured with attribute Fail_ALM which will alarm high (true) when process variable is out of range. Maintenance work requests should be immediately issued upon occurrences of these alarms. Maintenance requests should be classified by severity using normal WAM practices.
12.8.2 Alarms for Redundant Sensors and Voting Systems
Special considerations are required when defining and rationalizing alarms where multiple instruments are measuring the same process variable. This is most common where both a switch and transmitter are utilized for process measurement or two transmitters are used for redundancy.

When two transmitters are measuring the same process variable, the process control strategy and alarm management database shall define the methodology for voting as well as handling significant deviations between signals.

When a switch and transmitter are measuring the same process variable and alarm limits are configured for the transmitter signal, the transmitter alarms shall typically be configured to alarm at a lower limit than a high alarm switch and at a higher value than a low alarm switch. Ideally, the alarms derived from the analog sensor would be operating limits and the switches would be alarm limits. Alternately, the analog sensor limits could be high and low alarms and the switches could be assigned as high-high and low-low alarms. High-high and low-low alarms are considered extreme alarms and are secondary indications to follow high and low alarms. The switch alarm should be configured to override the transmitter alarm should the process trigger the switch but not the transmitter alarm.

12.8.3 Duplicate Alarms
Duplicate alarms shall be rationalized and modified such that there is only one alarm per abnormal condition. For example, if there are redundant level sensors in a wet well and the level exceeds the high, high-high, low, or low-low limit of both sensors, the two points should only trigger a single alarm. This can be done through “first in” logic in the PLC or by creating a common alarm point that can be triggered by either or both level sensors. The method that is used to prevent duplicate alarms from being indicated should be documented in the Process Control Description,

12.8.4 Flammable and Toxic Gas Detectors
All flammable, toxic gas, and low oxygen detector alarms shall be configured as Priority 1.

12.8.5 Safety Shower and Eyebath Activation Alarms
All safety shower and eyewash activation alarms shall be configured as Priority 1.

12.9 Management of Change
MOC policy includes modification or temporary modification of the alarm management system.

The following alarm system changes require approval in accordance with the MOC policy:

- Alarm limit or priority change
- New alarms
- Removal of alarm
- Alarm suppression
- Modification of alarm management strategy
- Modification of advanced alarm handling (filtering, time delay, etc.)
All approved modifications shall be required to update the master alarm database. Any alarms modifying the alarm management strategy shall update this document and supporting alarm rationalization documentation.

12.10 Training
Implementation of an alarm management strategy, in the form of either a new installation or a revision of an existing alarm configuration, requires operator and staff (engineers that deal with the alarm system) training. The training must cover several areas and include specific points.

Initial training shall be conducted prior to placing an alarm in service.

Operator training on alarm system shall include at a minimum:

- Audible and visual indication for alarms
- Distinction of alarm priority
- HMI features
  - Alarm Summary
    - Sorting/filtering
    - Acknowledge
    - Shelving
  - Navigation to associated display screen
- Procedures for removing an alarm from service (and restoring)
- MOC procedures for alarm modifications (limit, delay, filtering)

For new or modified alarms, the operator shall be trained on the following:

- Likely root causes for the alarm
- Consequences of not responding to the alarm
- Time to respond
- Recommended actions
- Alarm limit
- Alarm priority

In addition to the topics covered in operator training, the engineer training shall specifically cover implementation standards and testing.

12.11 Alarm Maintenance and Improvements Process
This section will include an overview of the District’s policies and work processes for maintaining an alarm system and the overall alarm management work process.

12.11.1 Alarm System Problem Detection and Resolution
The alarm system is configured to promote continuous monitoring. The alarm summary display will generate system errors for abnormal alarm management situations. System level errors should be addressed immediately by the PC&A department through generation of a work order.
Additionally, scheduled audits provide opportunity for early detection of anomalies that may be resolved before an error occurs.

12.11.2 Alarm Testing and Records
This section describes the routine and change based testing requirements for the alarm management system.

12.11.2.1 NEW OR MODIFIED ALARMS
Testing shall encompass the complete loop from instrument to HMI display and historical logging. Testing requirements are dictated by alarm classification. Test results, including test criteria, shall be recorded and all failures shall perform a WAM RFCA.

Alarm testing shall include:

- Verification of alarm limits or conditions
- Verification of correct audible and visual indication at HMI
- Verification of archiving in the historian alarm and event database
- Verification of other requirements documented in associated PCN (i.e., shutdown of equipment, local indicator signal, etc.)
- Loop check as required by alarm priority (reference recommended testing frequency table below)

Alarm system test shall include:

- Alarm message display
- Alarm summary display
- Alarm suppression
- Alarm shelving (and automatic resets)
- Alarm filtering and sorting

Note: Testing should be performed by driving the alarmed process variable into alarm state rather than modification of alarm limits.

12.11.2.2 ROUTINE TESTING
Routing testing of the alarm management system shall be performed to assure reliability of the alarm system. Testing shall follow the requirements in Section 12.11.2.1. The District asset reliability manager is responsible for scheduling of instrument calibrations. PC&A shall be included in annual testing of life safety instrumentation which interfaces with PCS and will perform concurrent alarm management system testing.

12.11.3 Alarm Management Policy Updates
Alarm management policy shall be reviewed annually and updated if there are significant changes to the process, operations policies or overall risk. Project based updates may be required if the project generates alarms that do not fall within the policies contained in this document.
13.0 Reference Documents

Table 13-1 contains a complete listing including live links to all referenced District standards and forms, and industry standards and best practices.

Table 13-1 Reference Documents

<table>
<thead>
<tr>
<th>Document Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control of Hazardous Energy (lockout/tagout) – 29 C.F.R. § 1910.147</td>
</tr>
<tr>
<td>ISA88, Batch Control Standard</td>
</tr>
<tr>
<td>ISA101, Human-Machine Interfaces Standard</td>
</tr>
<tr>
<td>NEORSD Asset Tag Abbreviations File</td>
</tr>
<tr>
<td>NEORSD Process Control Description Design Standard</td>
</tr>
<tr>
<td>NEORSD Standard Object Library Programming Guideline</td>
</tr>
<tr>
<td>One Point Lesson (OPL)</td>
</tr>
</tbody>
</table>

End of Volume 5
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Appendix A – Example Process Control Description
Appendix B – Alarm Management Database
Appendix C – Alarm Management Critical Process Areas