# APPENDIX E – PROCESS AND INSTRUMENTATION DIAGRAM REQUIREMENTS

## 1 SCOPE

1.1 This appendix describes the requirements for Process and Instrumentation Diagrams (P&IDs) format and content.

1.2 This appendix covers the generation of new P&IDs and does not apply to the revision of existing P&IDs. This appendix also applies to &IDs provided by packaged equipment vendors and contractors.

1.3 The requirements provided in this appendix provide a balance between showing all data on P&IDs and making P&IDs legible and easy to read. While this appendix is expected to incorporate the majority of requirements of most users, individual applications may involve requirements that will be appended to and take precedence over this appendix. Determinations concerning fitness for purpose and particular matters or application of the appendix to particular project or engineering situations should not be made solely on information contained in these materials.

## 2 APPLICATION

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

- All new facilities must comply completely.
- All major upgrades to a facility, or a larger facility's process area, must completely comply. Any existing instruments within the area being upgraded should be re-identified.
- All minor upgrades should utilize this appendix as far as practical, however in some cases compromises with the existing P&IDs may be required.

## 3 REFERENCES

3.1 City of Winnipeg Water & Waste Department (W&W)

- Water and Waste Department Electrical Design Guide
- Water and Waste Department Identification Standard

3.2 The Instrumentation, Systems, and Automation Society (ISA)

- ISA 5.1 – Instrumentation Symbols and Identification
- ISA 5.2 – Binary Logic Diagrams for Process Operations
- ISA 5.3 – Graphic Symbols for Distributed Control / Shared Display Instrumentation, Logic and Computer Systems
- ISA 84.01 – Application of Safety Instrumentation Systems for the Process Industries

3.3 The Government of Manitoba

- C.C.S.M. C W210 – The Workplace Health and Safety Act

## 4 DEFINITIONS

4.1 For the purpose of this Practice, the following definitions apply:

4.1.1 Accessible: Term applied to a device or function that can be used or seen by an operator for the purpose of performing control actions (e.g. set point changes, auto-manual transfer, or on/off actions) (Reference ISA 5.1)

4.1.2 Automated Valve: Any valve with a locally or remotely controlled actuator. Examples are throttling control valves and on/off block valves. Actuators are typically air-operated (diaphragm or piston), electric or hydraulic, some with spring return function. Manually operated valves are sometimes tagged as automated valves (e.g., if a manual valve is fitted with position switches).

4.1.3 Auxiliary P&ID: Used to show details to unclutter other P&IDs (e.g., lube oil system, sample systems, instrument details).

4.1.4 Basic Process Control System (BPCS): Control equipment and system installed to regulate normal production functions. It may contain combinations of single-loop pneumatic controllers, single-loop electronic controllers, Programmable Logic Controllers (PLCs), Supervisory Control and Data Acquisition (SCADA) and Distributed Control Systems (DCSs). The BPCS is required to operate the process. Examples of control functions included in the BPCS are cascade control, override control, and pump start/stop. Also known as Basic Regulatory Controls. (See also HLCS and SIS).

4.1.5 Bubble: Circular symbol used to denote and identify the purpose of an instrument or function. The bubble usually contains a tag number. (Synonym for balloon) (Reference ISA 5.1).

4.1.6 Design Pressure: Pressure used in the design of a vessel component together with the coincident design metal temperature for determining the minimum permissible thickness or physical characteristics of the different zones of the vessel. (Reference ASME Boiler Pressure Vessel Code, Section VIII, Division 1, Appendix 3)

4.1.7 Fail Closed (FC): Characteristic of an automated valve that causes the valve to close as a result of specific malfunctions, including loss of signal or motive power. (Reference ISA 5.1).

4.1.8 Fail Indeterminate (FI): Characteristic of an automated valve that causes the valve to move to an unknown position as a result of specific malfunctions, including loss of signal or motive power. Some automated valves will not stay at the last position upon failure and instead move with the process differential pressure. Additional equipment may be needed to meet the definition of FC, FO, or FL. (Reference ISA 5.1).

4.1.9 Fail Locked (FL) Last Position: Characteristic of an automated valve that causes the valve to remain in the last (locked) position as a result of specific malfunctions, including loss of signal or motive power. Automated valves may fail indeterminately without additional equipment. (Reference ISA 5.1).

4.1.10 Fail Open (FO): Characteristic of an automated valve that causes the valve to open as a result of specific malfunctions, including loss of signal or motive power. (Reference ISA 5.1).

4.1.11 Hand Switch (HS): Any operator-manipulated discrete control device, including hardwired panel switches and software points.

4.1.12 Heat Exchanger Type: Type designation shall be shell and tube, plate and frame, spiral, etc. For shell and tube exchangers, use the three-letter designation describing stationary head, shell, and rear end or head, in that order, in accordance with TEMA.

4.1.13 Higher Level Control System (HLCS): Provides sophistication above that of the BPCS. The HLCS is not necessary to operate the process. HLCS functions are typically based in process computers or higher level DCS hardware that interacts with the process by manipulating set points in the BPCS. Examples of control functions in the HLCS are statistical process control and model predictive control. (See also BPCS and SIS).

4.1.14 Interlock: System that, in response to a predetermined condition, initiates a predefined action. Typically comprised of binary (on/off) signals and logic used for process control, sequencing, or protective interruption of normal process control functions. Protective interlocks are typically further defined as being either safety-related or commercial-related (asset or production protection).

4.1.15 Isolation Valve: A valve used for isolation of process equipment while performing activities such as purging, de-pressuring or de-inventorying. This valve is also commonly referred to as the primary block valve.

4.1.16 Line Class: Section of the Piping Material Specifications that provides a listing of piping components for specific design conditions.

4.1.17 Logic Solver: Control equipment that performs the logic function. It can be either hardwired (e.g., relays) or Programmable Electronic Systems (e.g., DCS-based or PLC-based, including dual-redundant or triple-redundant microprocessors).

4.1.18 Packaged Equipment: One or more pieces of equipment furnished by a vendor with supportive devices and components to perform a specific operation as a unit.

4.1.19 Process and Instrumentation Diagram (P&ID): Detailed graphical representation of a process including the hardware and software (i.e., piping, equipment, and instrumentation) necessary to design, construct and operate the facility. Common synonyms for P&IDs include Engineering Flow Diagrams (EFDs), Utility Flow Diagrams (UFDs), and Mechanical Flow Diagrams (MFDs).

4.1.20 Programmable Electronic System (PES): Logic performed by programmable or configurable devices (Reference ISA 84.01).

4.1.21 Root Valve: First valve or valves between the process and an auxiliary device (e.g., an instrument) that contacts the process and is used to isolate the device from the process. This valve is typically a line class valve used for shut-off and isolation.

4.1.22 Safety Integrity Level (SIL): One of four possible discrete integrity levels (SIL 1, SIL 2, SIL 3, and SIL 4) of Safety Instrumented Systems. SILs are defined in terms of Probability of Failure on Demand (PFD). (Reference ISA 84.01).

4.1.23 Safety Instrumented Systems (SIS): Systems composed of sensors, logic solvers, and final control elements for the purpose of taking the process to a safe state if predetermined conditions are violated. Other terms commonly used include Emergency Shutdown System (ESD or ESS), Safety Shutdown System (SSD), and Safety Interlock System (SIS). (Reference ISA S84.01) (See also BPCS and HLCS).

4.1.24 Skirt: Cylindrical supporting structure, welded to the bottom of a vertical vessel and extended to the base support.

4.1.25 Tagged: For the purposes of labeling instrumentation and control components, a hardware device or a software point that is identified with a W&W or ISA style tag number.

4.1.26 Tight Shut-Off (TSO): Tight Shut-Off is defined in this Practice as ANSI Class V or ANSI Class VI in accordance with ANSI/FCI 70-2.

4.1.27 Trim: Item attached to equipment as an integral component, identified as part of the equipment that is exposed to the process, and having a function local to the equipment being served. Examples are vent and drain valves, instrument bridles, blind flanges, plugs, or other miscellaneous items associated with a piece of equipment. Typically, trim is purchased independently from the equipment

## 5 GENERAL REQUIREMENTS

5.1 Most details available from other types of documentation (e.g., instrument loop diagrams and vessel data sheets) should not be included on P&IDs.

5.2 This appendix uses the concepts of typical details with implied components where appropriate to simplify P&IDs.

5.3 While the intent of this appendix is to simplify the P&IDs through the use of implied components and cover sheets, this may not be compatible with the work processes or design software used for a project. Therefore, this Practice does not require the use of implied components. It is the responsibility of the project team to determine the compatibility of implied components with project needs and work.

## 6 DRAWING LAYOUT

*Comment: The layout and orientation statements specified herein are recommended as optimal and slight deviation, although not encouraged, may be required due to space constraints.*

6.1 General

6.1.1 Drawing size shall be consistent with the other drawings in the tender documents.

6.1.2 Each P&ID shall be laid out to avoid clutter and allow future modifications. No more than three pieces of major equipment shall be shown on a single P&ID. A set of pumps in the same service shall be one piece of equipment for the purpose of a P&ID layout.

6.1.3 Equipment arrangement shall be shown relative to its elevation to grade where practical.

6.1.4 A control valve actuator shall be shown above a horizontal line or left of a vertical line.

6.1.5 Typical details shall be used if clutter can be eliminated without detracting from clarity. These details shall be shown on the P&ID, on an auxiliary P&ID, or on a cover sheet

6.2 Flow Orientation

6.2.1 Primary flow shall be shown on each P&ID from left to right. Flow through equipment shall be shown relative to the actual arrangement, such as filter influent in the top of the tank and filter effluent out the bottom of the tank.

6.2.2 Primary process lines shall be shown as a heavier line weight than secondary and utility lines.

6.3 Connectors

6.3.1 Off-page connectors for primary, secondary, and instrumentation lines shall be shown entering the P&ID horizontally from the left inside the borderline and existing horizontally from the right inside the borderline.

6.3.2 Service description, connector number, P&ID number and origin/destination shall be shown for off-page connectors.

6.3.3 Origin/destination shall be shown as an equipment tag, line number or loop number.

6.3.4 Service description for a piping off-page connector shall be shown as name of fluid or line description.

6.3.5 Service description for instrumentation off-page connector shall be shown as a line function or equipment to be controlled.

6.3.6 Text associated with off-page connectors on the left side of the P&ID should be left justified; text associated with offpage connectors on the right side of a P&ID should be right justified.

6.4 Equipment

6.4.1 Information

6.4.1.1 Equipment numbers shall be underlined.

6.4.1.2 Equipment descriptions and data shall be immediately beneath the equipment number.

6.4.1.3 Equipment information for fixed or static equipment (e.g. tanks, vessels, filters, etc.) shall be shown immediately below the top borderline and motorized/rotating equipment (e.g. pumps, blowers, compressors, etc.) shall be shown immediately above the bottom borderline. Equipment numbers for the top or bottom identification shall be on the same horizontal plane as other equipment identification.

6.4.2 Symbols

6.4.2.1 Equipment symbols shall be as indicated in the facility P&ID legends where applicable or available.

6.4.2.2 Equipment shall be shown with a simple outline representation.

6.4.2.3 Discretion shall be exercised for equipment symbols to not dominate the drawing, but the symbols shall be drawn large enough for clear understanding.

6.4.2.4 Equipment shall not be drawn to scale.

6.4.2.5 Equipment shall be shown relative to associated equipment both in size and general orientation.

6.4.3 Nozzles

6.4.3.1 Nozzles, including spares, shall be shown on equipment as single lines.

6.4.3.2 Manways shall be shown as double lines.

6.4.3.3 Process and utility nozzles may be labeled.

6.4.3.4 Nozzle sizes shall be shown, unless the size is implied by piping connections.

6.4.4 Equipment identification shall be in accordance with Water and Waste Identification Standards.

6.4.5 Equipment elevations shall not be shown unless the elevations are necessary to specify process requirements for associated equipment location or orientation relative to one another.

6.4.6 Associated trim (e.g., vents, drain valves, etc.) for equipment shall be shown.

6.4.7 Jacketing and tracing requirements for equipment shall be shown.

6.4.8 The type of insulation (e.g., personnel protection, heat conservation) for equipment shall be shown as part of the equipment data. Insulation thickness shall be shown where applicable.

6.4.9 Drivers shall be shown with driven equipment and shall use the symbols for motors, and diesel/natural gas engines.

6.5 Instrumentation and Controls

6.5.1 Symbols

6.5.1.1 Instrumentation and control symbols shall be as indicated in the facility P&ID legends where applicable or available.

6.5.1.2 If necessary a descriptive text label may be added (e.g.

6.5.1.3 Directional arrows on instrumentation signal lines shall be used only if the function is not obvious.

6.5.1.4 Instrument function symbols shall be used to clarify the function of certain tagged instrument bubbles. The symbol shall be placed outside the bubble at the upper right.

6.5.2 Automated Valves

6.5.2.1 Automated valve fail actions shall be shown with text (i.e. FO/FC/FI/FL)

6.5.2.2 Valves with different fail actions for loss of signal and for loss of motive power require an explanatory note.

6.5.2.3 Valve body sizes shall be shown for all automated valves if not line sized or otherwise implied.

6.5.2.4 For automated valves, tight shut-off requirements shall be identified by using the abbreviation “TSO”.