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RECORD OF REVISION

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0	10/27/06	Had been Mech Chapter Section D10-30PFD. New Example Drawing numbers. Other administrative changes.	Mike Clemmons, *FM&E-DES*	Kirk Christensen, *CENG*
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CONTACT THE I&C STANDARDS POC

for upkeep, interpretation, and variance issues

Ch. 8, App I	**I&C POC/Committee**

ATTACHMENT I
PFD AND P&ID DIAGRAM REQUIREMENTS (PROGRAMMATIC & FACILITY)

1.0 GENERAL

A. This section defines the requirements for Process Flow Diagrams (PFDs) and Piping and Instrumentation Diagrams (P&IDs) for LANL systems.

B. P&IDs and PFDs meeting the requirements of this document are required for material handling/processing, piping, and HVAC systems when any of the following are true:

1. The systems are safety-related systems (definition per Z10).
2. When they have been designated as Priority Drawings per ESM Chapter 1 Section Z10.
3. As required by ESM Chapter 1 Section Z10.

C. *Guidance: P&IDs and PFDs are recommended for all complex mechanical systems.*

D. Use this Appendix in conjunction with the LANL Drafting Standards Manual for the development of complete drawings.

E. P&ID definitions are included in Attachment 1, Glossary, to this Appendix.

2.0 OVERVIEW *(GUIDANCE)*

A. *PFDs depict a given system's flows, temperatures, pressures and mass balances for various operating conditions. Such information is typically presented in the form of tables on the PFDs. PFDs present functional information about a system or subsystem. Components such as piping, pumps, and valves are represented by standard schematic symbols that illustrate their function in the system, as opposed to their relative sizes, locations, or physical shapes. Instrumentation and control information is not included.*

PFDs are typically the first drawings developed for a mechanical process, often in the preconceptual or conceptual design phase.

B. *P&IDs are typically developed from PFDs. P&IDs communicate detailed information on how to operate, troubleshoot, and repair or modify a system or subsystem. In addition to the mechanical components, they include instruments, signal modifiers, controllers, and their inter-relationships. They typically do not include tabular parameters as PFDs do.*

Terms associated with P&IDs are defined in Attachment 1 to this Appendix.

When PFDs are drawn carefully, P&IDs can be produced as additional CAD layers added to the PFD.

C. *PFDs and P&IDs are almost always limited to a specific system, and show supporting or interfacing components of other systems only to the extent necessary to allow the reader to understand the relevant interrelationships. The primary purpose of the P&ID is to bring together system information from various engineering disciplines (mechanical, electrical, control/instrumentation, et al) and present it in one drawing or drawing set to illustrate how a system works as a whole.*

D. *As a rule, PFDs and P&IDs do not have a drawing scale and usually present only the functional relationship or sequence of components. Two pieces of equipment that appear next to each other on the PFD or P&ID may not even be in the same building. Two pumps with widely different flow and pressure characteristics may be represented by similar symbols. Piping bends and relative lengths may or may not reflect the actual, as-built geometry in the field. In general, PFDs and P&IDs only present information on how a system functions, not the relative physical locations or spatial relationships.*

E. *PFDs and P&IDs are done in a "single line" format that represents all piping and ductwork as a single line regardless of size. Differences in piping function (e.g., primary flow, secondary flow, instrumentation, electrical, etc.) are indicated by varying the width or characteristics of the line. Pipe sizes are shown with text alongside the line.*

F. *The most common symbols used in PFDs and P&IDs are defined in Mechanical Standard Detail ST6999, Symbols, Process Flow and P&IDs. If a user or drafter encounters a component not covered in ST6999, one should refer to the reference subsection of this document for standards that contain additional, industry-accepted guidance. Creating unique symbols is highly discouraged, although situations may arise which are not covered in these publications. In that case, the designer should clearly define all symbols used in the drawing legend (begin with ST6999 and create a new project-specific legend sheet, adding to ST6999 symbols as needed).*

G. *ESM example diagrams are shown by the following LANL Standard Example drawings:*

D-6000, HVAC Air Flow Diagram
D-6005, Technical Facility Process Flow Diagram
D-6010, Technical Facility HVAC Process and Instrumentation Diagram
D-6015, Office Building HVAC Process and Instrumentation Diagram
D-6020, Cooling Water Process Flow Diagram
D-6025, Cooling Water Process & Instrumentation Diagram

3.0 FORMAT AND SYMBOLS

A. **Format**

1. PFDs and P&ID size, format, drafting layers, and software shall be in accordance with the LANL Drafting Standards Manual. PFDs shall be formatted as depicted in Example drawings D-6000, D-6005, and D-6020 . P&IDs shall be formatted as depicted in D-6010, D-6015, and D-6025.

2. *Guidance: PFDs and P&IDs should be specific to one system only (e.g., HVAC, Compressed Air, Tower Water, etc). Put another way, apart from system interfaces, no more than one system should be shown on a single diagram. See the approved system list Section 210 of LANL Engineering Standards Manual Chapter 1, and the discussion of system boundaries in Section 220.*

3. *Guidance: PFDs and P&ID should be configured such that major flow paths are shown from left to right and top to bottom, if possible. Primary flow paths should not suffer major changes in direction on the PFD or P&ID.*

B. **Drawing Symbols**

1. PFD and P&ID drawing symbols shall be in accordance with the standard legend and symbols provided in ST6999. *When producing drawings, refer to the LANL Drafting Standards Manual's Mechanical Drawings section and its related Appendix contains symbol files.*
2. Examples D-6000 through D-6025 shall be followed for the consistent layout and application of symbols. If not reflected in these referenced drawings, ISA-5.1, *Instrumentation Symbols and Identification*, shall be applied to the maximum extent possible.
3. Component numbering shall be as described by LANL Engineering Standards Manual Chapter 1, Section 200.

4.0 TECHNICAL DETAIL

NOTE on Setpoints: The Project Manager shall indicate where setpoints are to be controlled. If setpoints are documented by computer, database, or controlled list (preferred methods), then they shall not be repeated on drawings. However, the PM may direct that setpoints be on the drawings (e.g, P&IDs) vice a database or list.

A. *General Guidance:*

1. *Equipment, process flow paths, and interface nodes should be laid out to conform with the sequence of process flow and branching.*
2. *The physical arrangements or characteristics of tanks should be indicated (e.g., instrument connections, penetrations, internal baffles, jackets, spargers, heaters, etc.).*
3. *Each component should be shown only once on a PFD or P&ID sheet or series. If it is necessary for a component to appear on more than one PFD or P&ID, the subsequent appearances should be "ghosted" (shown in light gray color). This occurs most often when two systems are supporting the same component (e.g. heat exchangers).*
4. *If practical, the relative location of equipment (e.g., elevation) should be shown by position on the drawing. Although the main focus of a PFD or P&ID is to present functional information about the system, adhering to this good practice as much as possible makes it easier for drawing users to identify and locate equipment in the field. Additionally, room numbers may be added to clarify equipment and component locations.*
5. *When multiple major process components have identical process, utility piping and instrumentation, only one of the groups with all piping, control and instrumentation may be shown at the discretion of the Project Engineer. The remaining groups should be identified using a block diagram and tables to define valve and instrument numbers (P&ID only).*

6. *For PFDs and P&IDs, the following types of information should be shown, as applicable:*
   - *Mechanical equipment with component ID numbers. If only one system is shown on the drawing, system identifiers can be omitted (see ESM Ch 1, Section 200).*
   - *Main and secondary process lines, ventilation ducts and flow paths, instrument lines, electrical, pneumatic, and mechanical links.*
   - *Local and remote instruments and designations in sufficient detail to delineate the function(s) of the instrumentation and its interface with the process; PFDs should only show instrumentation and controls associated with key control valves or dampers.*
   - *Piping and duct code break boundaries. For example, a system boundary could delineate the break between the HVAC and Compressed Air systems; a piping code break boundary may depict a class break between B31.1 and B31.9 or metal and plastic piping.*
   - *Process valves and dampers including permanently installed high point vent and drain valves (with open and closed indications in their normal positions).*
   - *Permanently installed test connections.*
   - *Floor and wall penetrations (where practical).*
   - *Ductwork identification.*
   - *Glovebox or hood boundaries (only as needed).*
   - *Interconnection reference to other drawings including drawing number and grid coordinates.*
   - *Vendor interface boundary of skid mounted equipment.*
   - *Valve identification, type, actuator type, alignment (e.g., normally open, normally closed, failure state (e.g., fails open, closed), and locked position, as applicable.*
7. For P&IDs only, the following types of information should be shown, as applicable:
   - *Equipment Safety Classification boundaries, e.g., Safety-Class, Safety-Significant, etc (optional)*
   - *Instrument switches and relays (devices with the generic description of relays or switches that are actuated by a signal and are part of an instrument loop are classified as instruments; as such, these instruments should be shown on the P&ID, but not PFDs)*
   - *Sequence of operation (optional)*
   - *Tank/wall nozzles with identification*
   - *Heat tracing and type (e.g., steam or electric – include voltage as practical*
   - *Supplier package piping, valves, instruments and controls to the extent they require operator interface or response*
   - *Status indicating lights*
   - *Annunciation and computer inputs/outputs*
   - *Manual switches and pushbuttons*
8. *The following information should **not** be shown on a PFD or P&ID:*
   - *Electrical power supplies*
   - *Equipment rating and capacity*
   - *Electrical control relays (these non-instrument devices are not actuated by a signal and generally perform a function in the electrical control circuitry)*
   - *Pipe hangers and supports*

- *Supplier package piping which is internal to package and has no operational interface*
- *Standard pipe fittings (except in-line pipe size changes should be shown with a reducer-type symbol)*
- *Valve code*
- *Radiation shielding*
- *Test/Startup boundaries*
- *Extensive explanatory notes*
- *Physical details and dimensions*
- *Site jurisdictional boundaries*
- *Piping connections and type (e.g. threaded, flanged, etc.)*

B. **Electrical and Mechanical Equipment Guidance**

1. *Three way valves, pneumatic and solenoid actuated valves should be shown in the normal (shelf) state.*

C. **Instrumentation Guidance (P&ID only)**

1. General

- *All process measurement, process control, and equipment interlock devices that are required to operate, maintain, and control the system equipment should be shown. Illustrate distinctions between local and remote devices, as well as the location and/or panel on which the devices are mounted using appropriate bubbles per ST6999's Instrument/Function Symbols section.*
- *For setpoint requirements see beginning of this Content Subsection (above).*

2. Instrumentation and Control Logic

- *The P&ID should show the field sensing element, the type of input or output, the final indications or selections necessary to be seen on the control room operator's panel, and the presence of an interlock if applicable.*
- *Connection lines that represent a data highway (as shown on the legend sheet) should be used within the digital control system boundary.*
- *A diamond shaped symbol should be used to represent an input to or output from the DCS. Each symbol shall be labeled with an "A" for analog or a "D" for digital. One or more corners of each diamond should be darkened to represent the signal output direction(s). This clearly defines whether a signal is an input or output.*
- *The P&ID interlock symbol may be shown on the same P&ID or make reference to the applicable Control Logic Diagram. The drawing number should be shown at the upper right hand corner of the interlock symbol.*
- *As an alternative, the P&ID may contain a table in the general notes section that lists each loop and logic diagram associated with the interlocks depicted on the P&ID. Each of these drawings should be assigned a corresponding sequential integer beginning with one. The integer should be shown above the upper right hand corner of the interlock symbol referencing the corresponding loop or logic drawing. Generally, analog signal should reference a loop diagram, and digital signal should reference a logic diagram.*
- *All signals involved in an interlock should be shown in a concentrated location on the P&ID. If this is not practical, the use of logic continuations to lead the user to each signal involved in an interlock should be considered.*

- *Valve positioners need not be depicted in complete detail. See ISA 5.1 for options.*

D. **Duct and Piping Guidance**

1. *The following duct and piping information should be shown:*
   - *Expansion and other flexible joints*
   - *Pipe size changes, e.g., reducers*
   - *Piping and ductwork size*
   - *Flow direction*
   - *Piping material specifications (optional)*
   - *Measuring and restriction orifices.*
   - *Unducted air flow-paths*
   - *Drains, vents, test ports, and other startup and shutdown piping*
2. *Loop seals, siphon breaks, and other pipe configurations that explicitly affect system function should be shown but need not display size annotation.*

5.0 REFERENCES/BASES

1. ISA 5.1 Instrumentation Symbols and Identification (formerly ANSI/ISA S5.1)
2. ISA 51.1, Process Instrumentation Terminology
3. ISA 75 series on control valves
4. ASME Y14.40-2000 series on Graphical Symbols for Diagrams (same as ISO 14617)
5. DOE-HDBK-1016, Engineering Symbols, Prints, and Drawings
6. IEEE Standard 803.1-92 (r2000), Recommended Practice for Unique Identification in Power Plants and Related Facilities - Component Function Identifiers
7. LANL Standard Drawing ST6999, P&ID Legends, Sheets M-0001 and M-0002
8. LANL Drafting Standards Manual, Mechanical Drawings section and related Appendices

6.0 ATTACHMENTS

ATTACHMENT 1
GLOSSARY

The following definitions include terms often encountered in the development and use of P&IDs (Ref: ISA-51.1; for additional definitions, see ISA-51.1 and the ISA-75 series for control valves). Terms italicized in a definition are also defined, and may also be discussed above in App I proper.

Accessible - A term applied to a device or *function* that can be used or be seen by an operator for the purpose of performing control actions, e.g., *set point* changes, auto-manual transfer, or on-off actions.

Alarm - A device or *function* that signals the existence of an abnormal condition by means of an audible or visible discrete change, or both, intended to attract attention.

Assignable - A term applied to a feature permitting the channeling (or directing) of a signal from one device to another without the need for switching, patching, or re-wiring.

Auto-Manual Station - synonym for control station.

Balloon - Synonym for *bubble.*

Behind the Panel - A term referring to devices that are not *accessible* for the operator's normal use, as opposed to devices designated as *local* or front-of-*panel-mounted*. In a very broad sense, "*behind the panel*" is equivalent to "not normally *accessible* to the operator."

Binary - A term applied to a signal or device that has only two discrete positions or states. When used in its simplest form, as in "*binary* signal" (as opposed to "*analog* signal"), the term denotes an "on-off" or "high-low" state, i.e., one which does not represent continuously varying quantities.

Bubble - The circular symbol used to denote and identify the purpose of an *instrument* or *function*. It may contain a tag number. Synonym for *balloon*.

Computing Device - A device or *function* that performs one or more calculations or logic operations, or both, and transmits one or more resultant output signals. A *computing device* is sometimes called a computing *relay*.

Configurable - A term applied to a device or system whose functional characteristics can be selected or rearranged through programming or other methods. The concept usually excludes re-wiring as a means of altering the configuration.

Controller - A device having an output that changes to regulate a controlled variable in a specified manner. A *controller* may be a self-contained analog or *digital instrument*, or it may be the equivalent of such an *instrument* in a shared-control system. An automatic *controller* varies its output automatically in response to a direct or indirect input of a measured process variable. A manual *controller* is a *manual loading station*, and its output is not dependent on a measured *process variable* but can be varied only by manual adjustment. A *controller* may be integral with other functional elements of a control *loop.*

Control Station - A *manual loading station* that also provides switching between manual and automatic control modes of a control *loop*. It is also known as an *auto-manual station*. In addition, the operator interface of a *distributed control system* may be regarded as a *control station.*

Control Valve - A device, other than a common, hand-actuated ON-OFF valve or self-actuated check valve that directly manipulates the flow of one or more fluid process streams. In general, use of the designation "*hand control valve*" is limited to hand-actuated valves that (1) are used for process throttling, or (2) require identification as an *instrument*.

Converter - A device that receives information in one form of an instrument signal and transmits an output signal in another form. An instrument that changes a sensor's output to a standard signal is properly designated as a transmitter, not a converter. Typically, a temperature element (TE) may connect to a transmitter (TT), not to a converter (TY).

Detector - Synonym for *sensor*.

Digital - A term applied to a signal or device that uses *binary* digits to represent continuous values or discrete states.

Distributed Control System - A system, which while being functionally integrated, consists of subsystems, which may be physically separate and remote from one another.

Final Control Element - The device that directly controls the value of the manipulated variable of a control loop. Often the *final control element* is a *control valve*.

Function - The purpose of, or an action performed by, a device.

Instrument - A device used directly or indirectly to measure and/or control a variable. The term includes *primary elements*, *final control elements, computing devices*, and electrical devices such as annunciators, *switches*, and push buttons. The term does not apply to parts (e.g., a receiver bellows or a resistor) that are internal components of an instrument.

Instrumentation - A collection of *instruments* or their application for the purpose of observation, *measurement*, control, or any combination of these.

Local - Designates an *instrument*, *controller*, or control station which is installed in the vicinity of the component or device which it affects, as opposed to one mounted in a remote panel or control station. The word "field" is often used synonymously with *local*.

Loop - A combination of measurement or input devices, *instruments*, and/or control *functions* arranged so that signals pass from one to another for the purpose of *measurement* and/or control of a *process variable*.

Manual Loading Station - A device or *function* having a manually adjustable output that is used to actuate one or more remote devices. The station does not provide switching between manual and automatic control modes of a control *loop* (see *controller* and *control station*). The station may have integral indicators, lights, or other features. It is also known as a manual station or a manual loader.

Measurement - The determination of the existence or the magnitude of a variable parameter.

Monitor - A general term for an *instrument or instrument* system used to measure or sense the status or magnitude of one or more variables. The term *monitor* is very unspecific as it can sometimes meaning analyzer, indicator, or *alarm*. *Monitor* can also be used as a verb.

Monitor Light - Synonym for *pilot light*.

Panel - A structure upon which are mounted a group of *instruments*, and which houses the operator-process interface. A panel may consist of one or several sections, cubicles, consoles, or desks. A synonym for *board*.

Panel-Mounted - A term applied to an *instrument* that is mounted on a *panel* or console and is *accessible* for an operator's normal use. A *function* that is normally accessible to an operator in a *shared-display* system is the equivalent of a discrete *panel-mounted* device.

Pilot Light - A light that indicates which of a number of normal conditions of a system or device exists, as differentiated from an *alarm* light, which indicates an abnormal condition. The pilot light is also known as a monitor light.

Piping and Instrumentation Diagram (P&ID) - A schematic (diagrammatic) representation of the piping, ductwork, equipment, and instrumentation and controls showing the physical/functional relationship among the various components.

Primary Element - Synonym for *sensor* or *detector*.

Process Flow Diagram (PFD) - A schematic (diagrammatic) representation of the piping, ductwork, and equipment showing the physical/functional relationship among the various components for the purpose of depicting a given system's flow, temperature, pressure and mass balance relationships.

Process Variable - Any property of a process that can be expected to change during the normal operation of the process.

Program - A repeatable sequence of actions that defines the status of outputs as a fixed relationship to a set of inputs.

Programmable Logic Controller - A *controller*, usually with multiple inputs and outputs, that contains an alterable program.

Relay - A device whose *function* is to pass on information in some modified form. Relay is often used to mean *computing device*. The term "relay" also is applied specifically to an electric, pneumatic, or hydraulic *switch* that is actuated by a signal. The term also is applied to *functions* performed by a relay.

Scan - To sample, in a predetermined manner, each of a number of variables intermittently. The *function* of a scanning device is often to ascertain the state or value of a variable. The device may be associated with other *functions* such as recording and alarming.

Sensor - That part of a *loop* or *instrument* that first converts the value of a process variable into a corresponding, predetermined, and intelligible state or output. The sensor may be separate from or integral with another functional element of a *loop*. The sensor is also known as a detector or *primary element*.

Set Point - An input variable that sets the desired value of the controlled variable. A set point may be manually set, automatically set, or programmed. Its value is usually expressed in the same units as the controlled variable.

Shared Controller - A *controller* containing preprogrammed algorithms that are usually *accessible, configurable,* and *assignable*. It permits a number of *process variables* to be controlled by a single device.

Shared Display - The operator interface device (commonly a video screen) used to display process control information from a number of sources at the command of the operator.

Switch - A device that connects, disconnects, selects, or transfers one or more circuits and is not designated as a *controller*, a *relay*, or a *control valve*. As a verb, the term is also applied to the *functions* performed by switches.

Test Point - A process connection to which no *instrument* is normally connected, but which is intended for the temporary or intermittent connection of an *instrument*.

Transducer - A general term for a device that receives information in the form of one or more physical quantities, modifies the information and/or its form, if required, and produces a resultant output signal, usually electric. Depending on the application, the transducer can be a *primary element, transmitter, relay, converter* or other device. Because the term "transducer" is not specific, its use for specific applications is not recommended.

Transmitter - A device that senses a *process variable* through the medium of a *sensor* and has an output whose steady-state value varies only as a predetermined *function* of the *process variable*. The *sensor* may or may not be integral with the transmitter. Transmitters frequently convert physical input process signals into electrical outputs.