HNF-64103
Revision 0

Preparation of Process Flow Diagrams and Piping and Instrumentation Diagrams

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

Contractor for the U.S. Department of Energy
under Contract DE-AC06-09RL14728

P.O. Box 650
Richland, Washington 99352

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Preparation of Process Flow Diagrams and Piping and Instrumentation Diagrams

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1.0 PURPOSE

This Standard provides guidance on the preparation of process flow diagrams (PFDs) and piping and instrumentation diagrams (P&IDs) produced for Mission Support Alliance (MSA). This standard updates the previous standard HNF-31672, *Preparation of Process Flow Diagrams and Piping and Instrumentation Diagrams*.

2.0 SCOPE

This standard applies to the creation of new PFD and P&ID engineering drawings for MSA. The standard comprises the minimum direction for developing and modifying PFDs and P&IDs. Existing PFD and P&ID drawings created to previous standards may be modified using the standards to which they were created. At the discretion of the Design Authority (DA), drawings created to previous standards may be updated to this new standard.

This Standard is used in conjunction with CAD and drawing standards contained in HNF-64101, *Preparation and CAD Data File Standards for Engineering Drawings*, and HNF-64102, *Preparation and CAD Data File Standards for Legacy Engineering Drawings*. The procedure for creation and control of engineering drawings is MSC-PRO-ENG-709, *CAD and Drawing Development and Control Process for Engineering Drawings* and HNF-14660 *Offsite Subcontractor Instructions for Preparation and Control of Engineering Drawings*.

3.0 STANDARD

3.1 Preparation of Process Flow Diagrams

The PFD is developed to give needed data to design disciplines in the early stages of engineering design as well as to operations after project turnover. The PFD is a simplified schematic description of a process, including the following elements:

- Basic equipment and stream flows necessary to define the process
- Temperatures, pressures, flow rates, and duties that define normal operation
- Material balances that define the quantities of raw materials and products, and the physical and thermal condition of every major stream in the process
- Instrumentation sufficient to illustrate the basic Process Control concept

This is accomplished using specific symbology traceable to a legend for identifying equipment, piping, instrumentation, and process lines.

The PFD accomplishes the following:

- Serves as a starting point for defining the process
- Establishes interrelation between equipment and controls that will accomplish the process goal
- Establishes material and energy balances and process conditions

- Provides information to other disciplines actively involved in the design work
- Provides the starting point for equipment list and datasheets, line sizing, modes of control, instrument datasheets, P&IDs, safety evaluations, and material selection
- Provides a check for overall process continuity and integrity
- Serves as a basis for other system sketches, diagrams, and engineering documentation that includes the following:
    - Operating and design conditions
    - Materials selection, Materials Selection Diagram
    - Line sizing
    - Temperature and pressure profiles
    - Safety and isolation
    - Process Control philosophy
    - Control and non-control instrumentation
    - Winterization and insulation
    - Environmental emissions diagram
    - Preliminary safety review
- Provides a means to develop and review operating procedures
- Provides a basis for a proposal.

3.1.1 Responsibility

At project turnover the MSA Design Authority/System Engineer will assume responsibility for the PFD.

PFDs are updated even after P&IDs are issued, and kept current, because they record process information used to coordinate and design the project and ensure that the proper process variables will be specified for the process piping, equipment, and instrumentation.

3.1.2 Process

3.1.2.1 Format and Overall Arrangement

- PFDs are created using the CAD and drawings standards given in HNF-64101.
- See Figure A-1 for a PFD example.
- Process flow on the drawing is generally from left to right.
- PFDs must be arranged to allow for future revisions.
- Limit detail to a level commensurate with project status. Excessive detail at an early stage only complicates changes. Details are picked up on P&IDs.
- An overall PFD may be made for processes with many PFDs to enhance understanding of the process.
- Only major equipment and flows are shown; startup, bypass, and minor lines with unspecified flow rates are not shown unless the system is very simple.

- PFDs should be presented on only one sheet, if possible. A BFD (Block Flow Diagram) may be appropriate and serve the intended purpose in place of a PFD.

3.1.2.2 Equipment Arrangement

- Major process equipment should be shown and arranged on the PFD using the normal sequence of flow. For visual understanding, relative equipment elevations should be used, particularly where gravity flow is involved.
- Relative equipment sizes should be shown, such as tanks of differing heights or diameters.
- Major equipment internals are to be shown only if improved understanding of the process results.
- Do not show detail items such as vortex breakers, flanges, or man ways.
- Do show decanting baffles, strategic trays (top, bottom, and feed), and demisters. Number trays from bottom to top.
- Identify tube side versus shell side flow through exchangers.
- Control valves and seal legs may also be shown to clarify operation and control scheme.
- Pumps, compressors, and blowers can be located where convenient. The preference is to locate pumps slightly below their suction vessels.
- Do not crowd the diagram. Limit the number of equipment items on a drawing so that adequate space remains for future revisions.
- If more than one frame is required for the process equipment, frames should be grouped into logical subsystems; for example, reaction and product recovery.
- Show equipment numbers within the outline of the equipment, if possible, otherwise next to the item.
- Both equipment numbers and names of equipment are generally shown on the top of the drawing above the equipment except for pumps, compressors, and exchangers where the names are located next to the equipment. Other information may be added if it is necessary for understanding the process.
- Designations must match the equipment list, equipment datasheets, and P&IDs.
- Operating pressures and temperatures should be shown within equipment outlines.
- Usually, only one of multiple identical train units and spared equipment should be shown. The equipment number will indicate the other trains or spares.
- Typical equipment items which should not be shown on the PFD are as follows:
    - Utility systems (for example, refrigeration, cooling water, tempered water, and hot oil)
    - Chemical feed systems, which require separate PFDs if sufficiently complicated or if considered necessary
- Packaged units can be shown as boxes if they are not important to understanding the process. If important, the essential details may be shown enclosed by dotted lines or by appropriate labeling.
- Drives are not normally shown on PFDs unless they are part of a control loop.

- An exception may be made when a drive is part of a standard equipment symbol.
- Equipment design conditions with material of construction are sometimes shown on separate PFDs.

3.1.2.3 Material Balance

- The material balance for normal operating conditions or batch operation is shown as a table in the lower left portion of the drawing. If additional space is needed to show the table, it is placed on a continuation sheet of the PFD. The following table provides an example of a Material Balance Format:

Material Balance Format					
Component	MW	Stream Number			
		1		8	
		Benzene Feed		Reactor Product	
		Mol/hr	Lb/hr*	Mol/hr	Lb/hr*
Hydrogen	2				
Methane	16				
Nitrogen	28				
Benzene	78.1				
Total					
Total (lb/hr)*					
Standard Cubic Feet Per Minute (SCFM)					
Gallons per Minute (GPM), at operating conditions					
Density at operating conditions, lb/ft3					
Viscosity, Centipoise (cP)					
Pressure, pounds per square inch gage (psig)					
Operating Temperature, degrees F					
* Component mass flow listing is optional. If not listed, show the total mass flow on a separate line.					

- If more than one operating case is presented, completely separate PFDs should be used. Where only minor differences exist between two or more cases, they may be shown on the same PFD with the appropriate designations.
- Stream numbers and descriptions should be consistent with calculations and computer simulations.
- The order for components should be from the lowest to the highest molecular weight (from top to bottom of the material balance). If a component is not present on a sheet (even if it is on others), it may be deleted from the material balance if the space is needed.
- Stream numbers should increase from left to right on the material balance. Identical numbers and descriptions should be maintained on any stream shown on more than one sheet.
- The following data are typically provided on a PFD material balance table

- Component molecular weight
- Component molar flow (moles per hr to nearest 100th)
- Component mass flow (optional, lb per hr to nearest lb)
- Total mass flow, pounds per hour
- Total volumetric flow
- Gases, Standard cubic feet per minute (scfm)
- Liquids, gallons per minute (gpm) at operating conditions
- Stream density (substituting specific gravity for liquids is optional)
- Stream viscosity, cP
- Operating pressure, pounds per square inch gage (psig) or pounds per square inch absolute (psia)

- Utility flows are not shown in the material balance table, unless they become part of a process stream. Utility flows are sometimes shown on the utility line.
- Batch processes should utilize batch quantities and cycle times in the Material Balance Table.

3.1.2.4 Lines

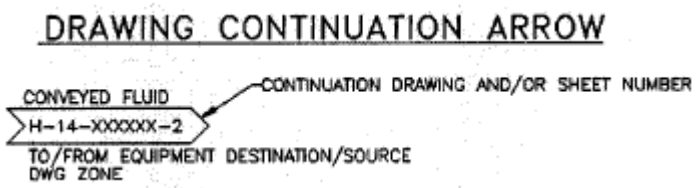
- Main process streams are shown in heavier weight lines (thick) lines for ease of following the process.
- Minor lines such as intermittent flows, startup lines, shutdown lines, and blowdowns are generally not shown.
- Where lines are designated by stream numbers, pressure and temperature information at that point should also be given.
- Utility lines are pigtailed to indicate tie-in points and type of utility only. They are not carried to the edge of the page. Next to the pigtail, show appropriate utility abbreviation symbol. Steam lines are to be identified with pressure in psig.
- Minimize crossing of lines. Process lines have priority over utility lines and utility lines have priority over instrument lines. Utility lines are broken when they cross process lines, and instrument lines are broken when they cross process or utility lines. Otherwise, vertical lines are broken when they cross horizontal lines.
- Flow arrows are used liberally to indicate flow direction. As a minimum, arrows are located at the end of a line and when the line changes direction.
- The following lines should not be shown:

  - Decommissioning
  - Sewers
  - Vents and drains

3.1.2.5 Relief Headers

- Lines showing the transition to and from multiple trains are shown on the PFD.

- Lines entering and leaving the flow sheet are identified by the conveyed fluid, source or destination, equipment name and number, and drawing number:



- Process tie-ins should extend to and from the edge of the drawing.
- Normal operating temperatures are indicated on inlet and outlet process streams associated with heat exchangers.
- Valves (except control valves) are generally shown as gate valves.

3.1.2.6 New Process Flow Diagrams Master Legend Drawings

The following drawings are the master listing of symbols for new PFDs. New PFD drawings generated for use at the Hanford Site shall comply with the symbology provided in the drawing references below.

Should a symbol be needed that is not covered by the PFD Master Symbology, consult the appropriate national consensus standards for the correct symbology; if no symbology is available, it is permissible to develop the needed symbology by adding it to the PFD legend.

Each symbol on a PFD shall be traceable to a legend. PFD drawings must have a legend on the drawing or they must reference a legend drawing developed using these criteria. These drawings are not to be used directly as legends for other drawings.

- H-9-6010 Sheets 1 thru 6, Master PFD and P&ID Legend,
- H-9-6015 Sheet 1, Master Abbreviations,
- H-9-6020 Sheets 1 and 2, Master Electrical Elementary and One-Line Legend,
- H-9-6021 Sheet 1, Master Electrical Plan Legend

The symbology specified by the following drawings is optional. It is provided as a drafting aid to increase efficiency in producing drawings. These drawings are not to be used directly as legends for new PFDs or P&IDs.

- H-6-l 4982 Hanford Standard, General Symbology,
- H-6-14983 Hanford Standard, Civil Symbology,
- H-6-14984 Hanford Standard, Structural Symbology,
- H-6-14985 Hanford Standard, Architectural Symbology,
- H-6-14986 Hanford Standard, Machine Symbology,
- H-6-14987 Hanford Standard, HVAC Symbology,
- H-6-l 4988 Hanford Standard, Fire Protection Symbology,
- H-6-14989 Hanford Standard, Control Systems Symbology,
- H-6-14990 Hanford Standard, Electrical Symbology,

- H-6-14991 Hanford Standard, Piping Symbology

3.1.2.7 Instrumentation

- Only the loops and instruments required to understand normal process operation and control should be shown.
- No alarms, safety instrumentation, or indicators are shown unless required to
- understand normal process operations.
- Instrument control lines are shown dashed regardless of signal type such as pneumatic and electronic.
- Do not show whether a controller is indicating or recording, local or panel, hardware or software, unless it is important to understanding basic control philosophy.
- Continuous online analyzers are shown according to Instrument Society of America (ISA) standards.
- The type of flow measurement device is not shown.
- The location of instrumentation on trayed columns must be clearly shown as to which tray it is on.

3.1.3 Miscellaneous PFDs

- PFDs that show feed and product tankage may be required.
- PFDs may be required for special process situations such as startup, catalyst conditioning, regeneration, and cleaning.
- Additional PFDs can be required to describe complex systems associated with the main process.
- PFDs can be modified to show air and water (liquid waste) emissions. These diagrams are usually renamed and become part of the Environmental Permit Package

3.2 Development of Piping and Instrumentation Diagrams

Standardized P&IDs allow personnel to quickly get a detailed look at the system and understand its operation. The directions contained in this instruction are of a general nature and are considered minimum format directions needed to achieve a consistent quality P&ID.

- P&IDs provide the single most important source of information for the project, the client, and the design disciplines in the early stages of engineering design and provide documentation for configuration control. The development should be the result of an established and orderly process.
- P&IDs are, by their nature, a document that requires multi-discipline input.

This Standard details the requirements for Piping and Instrument Flow Diagrams and, except as noted, this standard is in agreement with Process Industry Practices (PIP) national standard.

This Standard comprises the minimum direction for developing P&IDs that is needed for design disciplines during engineering design as well as for configuration control by engineering and operations after project turnover.

3.2.1 Flow Diagram Presentation

The principal objectives in the layout of a flow diagram are to:

- Clearly convey design information in an orderly manner consistent with FH requirements and industry practices
- Minimize rework that may be required by subsequent revisions to the drawing.

3.2.2 General Layout Preparation

When initiating the layout of a P&ID, a brief review of the following considerations will greatly enhance the final appearance and quality of the drawing:

- P&IDs are created using the CAD and drawings standards given in HNF-64101.
- Review and confirm the extent of equipment, piping, and instrumentation to be included on the drawing with the initiator of the P&ID and consider the possibility of equipment, piping, or instrumentation that may be added later.
- Investigate similar systems on other flow diagrams to ensure consistency among drawings in the same package.
- Identify major process streams.
- Investigate origins and destinations of lines entering and leaving the drawing.
- The following concepts should be observed:
    - The final drawing should have an appearance of uniform density. Components should be arranged in such a manner that an inordinate amount of information is not incorporated into a confined area.
    - The process should read from left to right across the page; that is, feed stock should enter on the left and product should exit on the right. There should be continuity of the process stream flow from sheet to sheet.
    - Primary process lines should be kept as direct and uninterrupted as possible. Their paths should take priority over secondary process lines (such as bypasses and jump-overs) and utility lines. Piping arrangement should take priority over instrumentation configuration.
- Establish the unit of measure for the project: English or metric. Examples given in this document use English units. Individual projects may use metric or English.

3.2.3 Piping and Instrument Diagrams (P&ID)

P&IDs contain the greatest amount of detail of any type of flow diagram. With few exceptions, all equipment, piping, and instrumentation are shown in schematic representation.

3.2.3.1 P&ID Layout

Due to their nature as an evolutionary document, P&IDs offer the greatest challenge as a layout exercise. The extensive level of detail required on these drawings demands that the designer anticipate special requirements of design information that evolves later in the developmental process. The content of individual P&IDs is generally determined by the Process Engineer.

The following procedure will serve as a basic guide for P&ID layout:

- Review the comments in Section 3.22, General Layout Preparation.
- Read the entire system sketch, and resolve any questions prior to initiating the drafting process.
- Locate line continuations for adjacent drawings.
- Allocate space in the drawing area for equipment titles, notes, details, and other text type information.
- Establish preliminary locations for equipment and preliminary routes for major process streams.
- Use this preliminary framework as a skeleton upon which detailed information can be added.
- See Figure A-2 for a P&ID example.

Note: Develop the entire drawing simultaneously. Do not completely detail one area before starting another. This will prevent unnecessary rework required by subsequent information that requires more space than expected.

After building a preliminary framework, work through the drawing adding detailed information in accordance with Section 3.2.3.3 Equipment (General Instructions).

3.2.3.2 New Piping & Instrumentation Diagrams (P&ID) Master Legend Drawings

The following drawings are the master listing of symbols for new P&IDs. New P&IDs drawings generated for use at the Hanford Site shall comply with the symbology provided in the drawing references below.

Should a symbol be needed that is not covered by the P&ID Master Symbology, consult the appropriate national consensus standards for the correct symbology; if no symbology is available, it is permissible to develop the needed symbology by adding it to the PFD legend.

Each symbol on a P&ID shall be traceable to a legend. P&ID drawings must have a legend on the drawing or they must reference a legend drawing developed using these criteria. The following drawings are not to be used directly as legends for other drawings.

- H-9-6010 Sheets 1 thru 6, Master PFD and P&ID Legend,
- H-9-6015 Sheet 1, Master Abbreviations,
- H-9-6020 Sheets 1 and 2, Master Electrical Elementary and One-Line Legend,
- H-9-6021 Sheet 1, Master Electrical Plan Legend.

The symbology specified by the following drawings is optional. It is provided as a drafting aid to increase efficiency in producing drawings. These drawings are not to be used directly as legends for new PFDs or P&IDs.

- H-6-l 4982 Hanford Standard, General Symbology,
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- H-6-l 4988 Hanford Standard, Fire Protection Symbology,
- H-6-14989 Hanford Standard, Control Systems Symbology,
- H-6-14990 Hanford Standard, Electrical Symbology,
- H-6-14991 Hanford Standard, Piping Symbology.

3.2.3.3 Equipment (General Instructions)

This section of the Standard provides instructions for depicting equipment and associated data on the P&ID, for example:

- Ensure equipment titles on P&IDs are identical to those on the equipment list.
- Show equipment numbers (underlined) adjacent to the equipment outline.
- Show critical dimensions or elevations between equipment required for process reasons. For example, elevation of vessels required for gravity flow.

3.2.3.4 Vessels / Columns

- Show the following information at the top of the drawing above the vessel/column:
    - Vessel/Column number
    - Title
    - Size (inside diameter (ID) x length tangent to tangent)
    - Design pressure and temperature
    - Number and type of trays; tray spacing
    - Number of packed beds, bed height, type and size of packing
    - Materials of Construction (MOC) for shell/tray/packing.
- Show Lines, instrumentation, and sample connections.
- Show packing, demisters, vortex breakers, and chimney trays.
- Verify tower internals are properly shown including:
    - Catalyst beds
    - Packing (Identify height and size [if required] of packing)
    - Demisters
    - Chimney trays,

- Draw-off trays
- Any other internals

- Verify equipment title and number is identical to that shown on the Equipment List and the Process Flow Diagrams.
- Verify that design information, such as dimensions, design pressure, and temperature, insulation requirements are consistent to the Equipment Datasheet.
- Verify that Materials are consistent with the Material Selection Diagram, if applicable, and with the Equipment Datasheet.
- Depict vessels relative size. For example, do not show an overhead accumulator larger than the associated tower.
- Show vessel internals in dashed lines to depict dip legs, coils, baffles, tube bundles, vortex breakers, demisters, catalyst beds and supports, and internal piping supplied by the equipment vendor.
- Show vessel nozzle sizes and designations inside the vessel, or outside the vessel and beside the nozzle, if needed.

    - Show the nozzle connection type (flange or special fitting).
    - Show valves located directly on the vessel nozzle are depicted with no pipe between nozzle and valve.

- Show access ways and hand holes

    - Show tangential nozzles in proper orientation.

- Show vessels in elevation view only.
- Verify tower internals are properly shown including catalyst beds, packing, demisters, chimney trays, draw-off trays, and any other internals with height and size (if required) of packing identified.
- Show height of bottom tangent line of vertical vessels above grade. For horizontal drums, show height of bottom above grade. Verify the height consistent with the pump requirement. Unmarked elevations indicate "Minimum."
- Show agitator, type, speed (revolutions per minute [rpm]), motor horsepower (HP), and MOC, equipped of a vessel and show agitators in a solid line (not a dashed line), along with the agitator equipment number.

3.2.3.5 Air Coolers

- Show the following information at the top of the flow diagram above the air cooler outline:

    - Equipment Number (underlined)
    - Equipment Title (underlined)
    - Design Duty: 1000 British Thermal Units (MM BTU) / hour (Hr); extended surface, ft2

- Design Pressure and Temperature / Minimum Temperature
- Material:
- Insulation: (Symbol for type or "None")
- It is permissible to show air coolers with only one bay represented, with a note detailing the actual number of bays required with all instrument tag numbers, shown in a tabulation format in a table.

- Show type of fan pitch control (auto variable / manual).
- Show winterizing details such as louvers, steam heating coils, etc.
- If symmetrical inlet and outlet piping is required for multiple bay air-cooled exchangers, show the actual piping scheme with a note highlighting this requirement.

3.2.3.6 Shell and Tube Heat Exchanger

- Show the following information at the top of the flow diagram above the exchanger outline:

  - Equipment Number (underlined)
  - Equipment Title (underlined)
  - Design Duty: MM BTU/ Hr
  - Shell Design Pressure and Temperature
  - Tube Design Pressure and Temperature
  - Materials:
    Shell:
    Tubes:
    Insulation: (Symbol for type or "None")

- Show correct Tubular Exchanger Manufacturers Association (TEMA) type of exchanger, number of shells or sections, flow arrangement, etc. For TEMA symbology for types of exchangers, see the master PFD and P&ID Legend Drawing H-9-006010, Sheet 3.
- Place the equipment number (underlined) adjacent to the exchanger outline
- Note the height of the exchanger above grade if it is elevated for a process reason, other reference points are permissible; for example, overhead condensers.
- On steam-heated reboilers, provide pressure indication on the steam and condensate systems.
- Show shell and tube exchangers that are in a stacked configuration in an elevation view. This is necessary to show the true flow scheme through the shell side of the exchangers. This will also allow the illustration of all necessary trim valves, vents, and drains.
- Show single shell and tube exchanger in an elevation view to maintain the pictorial consistency on the P&ID.
- Show double pipe exchangers in an end view. This is necessary to allow the flexibility of showing the correct piping hook-up of multiple units.

3.2.3.7 Pumps

- Show the following information at the top of the flow diagram above each operating pump:
    - Equipment Number (underlined)
    - Equipment Title (underlined)
    - Design Capacity: Rated Flow (in hot gpm) at Design Differential Pressure (in
    - pounds per square inch [psi])
    - Brake horsepower (BHP)/Motor HP
    - Material
    - Case
    - Impeller
    - Insulation (symbol for type or "None")
    - Cooling Water, Flushing Oil, Seal Oil, etc. required
- Show correct type of pump and driver. For symbology covering the types of pumps and drives, see the FH master PFD and P&ID Legend Drawing H-9-006010, Sheet 3, (Section B.6.2).
- Show the size of pump suction and discharge flanges. Show swages to suction or discharge piping.
- For positive displacement pumps, show external relief protection.
- For jacketed pumps, show heating fluid details and piping.

3.2.3.8 Compressors, Blowers and Fans

- Use the appropriate equipment symbol showing each type of compressor (see section 3.2.3.2). If multistage reciprocating, show each stage separately with only one driver.
- The following information is shown at the top of the flow diagram above each compressor outline:
    - Equipment Number (underlined)
    - Equipment Title (underlined)
    - Number of Stages:
    - Design Capacity: Inlet Cubic Feet Per Minute (ICFM)
    - Differential Pressure: psi
    - BHP/ Driver HP:
    - Materials:
- Place the equipment number (underlined) under each compressor symbol along with the stage number, which denotes spares.
- Show compressors in process units in proper respect to other process equipment. However, show auxiliary systems such as lube oil and seal oil systems on a separate auxiliary P&ID.

- Show blowers, fans and reciprocating compressor information such as suction / discharge pulsation dampeners, intercoolers.
- Show symbology as specified in the master PFD and P&ID Legend Drawing H-9-006010, Sheet 3, (Section 3.2.3.2).

3.2.3.9 Tanks

- Show the following information at the top of the flow diagram above the tank outline:
    - Equipment Number (underlined)
    - Equipment Title (underlined)
    - Inside Diameter (in feet) and Height (in feet)
    - Net Capacity: Gallons (or Barrels)
    - Design Pressure, psia or inches H20
    - Design Temperature, °F
    - Material:
    - Insulation: Type or None
    - For symbology covering the types of tanks, see the master PFD and P&ID Legend Drawing H-9-006010, Sheet 3, (Section 3.2.3.2).

3.2.3.10 Miscellaneous Equipment

- Use the appropriate equipment symbol showing each type of equipment (see section 3.2.3.2).
- Package equipment will be enclosed by dashed lines, within the dashed lines enter the words "Provided by Supplier" with the assigned Vendor Information number.
- Show the following information at the top of the flow diagram above the equipment outline:
    - Equipment Number (underlined)
    - Equipment Title (underlined)
    - Design Conditions*
      (*Each type of miscellaneous equipment will have its own type of pertinent design condition information. Choose the most important information needed for operations and add the information to the flow sheet.)
    - The information given will depend on the particular type of equipment. The design information could include any of the following items:
      Design Capacity: (GPM or Barrels Per Stream Day (BPSD) or Lbs / Hr)
      Design rating (XX psig at XX 0 F)
      Differential Pressure (DP): (XX psi)
      Dimensions: (envelope or overall)
      HP: (rating)
      Micron Size

3.2.4 Instrumentation

Utilizing knowledge of the process system and the PFD, the process engineer will specify on the P&ID the basic system control scheme or process conditions measured by instrumentation, and the principal piping and valve sequencing and locations necessary to accomplish the intended result. The control systems engineer will be primarily responsible for evaluating this scheme and accurately depicting the details of the instrumentation on the P&ID. In the initial layout of any P&ID, both Process and Control Systems engineers must be alert to allow plenty of drawing space for instrument symbols.

All instrument and control design and symbology corresponds with the applicable standards of the Instrument Society of America (ISA-SS.l) and Institute of Electrical and Electronic Engineers (IEEE). In cases of conflict with these national standards, the following drawings take precedence.

- H-9-006010, Sheets 1 through 6, Master PFD and P&ID Legend Drawing
- H-9-006015, Sheet 1 Master Abbreviations Legend Drawing
- H 9-006020, Sheet 1; Master Electrical Elementary and One-Line Legend Drawing
- H-9-006021, Sheet 1, Master Electrical Plan Symbology Legend Drawing.
- Also, see Section 3.2.3.2.

3.2.4.1 General

- Most, but not all, central control electronics will be a DCS (Distributed Control System) with an auxiliary host computer system. The following are remarks based on DCS.
    - Use a DCS to perform all continuous process control where frequent set point changes or continuous monitoring/alarming is required.
    - Implement local pneumatics for continuous control loops in non-critical service where frequent set point changes are not envisioned,
    - Generally, a DCS is not used for equipment interlocking, remote start or for handling critical alarms.
    - Design separate alarm wiring to a separate annunciator system in a control room.
- Show the proper location for all sampling points, particularly to analyzing instruments. Input from vendor may be required.
- Show all flushing and purge connections for instruments. Detail this design on the right-hand side of the flow diagram (typically done by Control Systems).
- Show all alarms, solenoid valves, timers.
- For simple logic, show all detail logic; for example, Pump Shutdown on low liquid level.
- For complex logic, show a logic table for the location of the equipment, or show it on a separate P&ID, or logic diagram.
- Complex control systems, such as compressor and fired heater shutdown systems, will be provided with "first-out" indication so that the operators can determine what first caused the problem.

- Provide unique identification to all instruments shown on the P&ID.

3.2.4.2 Control Valves

- In general, control valve stations have block valves and a by-pass.
- Show size and action (fail close, open, or last position) of control valves. Also, show by-pass valve size.

3.2.4.3 ReliefValves

- For Pressure Safety Valve (PSVs), show size of valve with orifice designation, valve number, and set pressure.
- Tag block valves on the P&ID that are locked or car sealed open (a tamper evident safety/security seal). Identify the tagged valves on the P&ID as full port valves.
- Provide a drain valve or a plugged drain between the block and PSV.

3.2.4.4 Thermal Reliefs

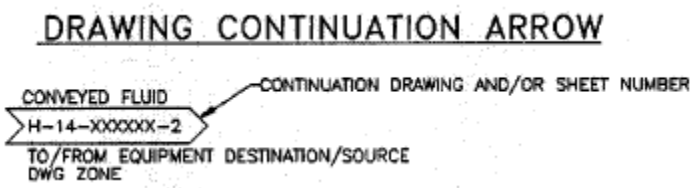
- To prevent overpressure during a blocked-in condition because of heat input, provide lines with a thermal relief if the pressure can build up to 1.5 times the design pressure. Lines included here are liquid filled lines which can be blocked in at both ends.
- Evaluate steam traced lines, cold solvent lines, refrigerant lines, long transfer lines, lines to tankage, and exchangers that have inlet and outlet blocks on the cold side.
- Thermal reliefs in water service will discharge to grade. In liquid hydrocarbon service, they will discharge usually to the nearest safe drain.
- All coolers using water will have a thermal relief valve on the cooling water return line between the cooler and the block valve.

3.2.5 Piping

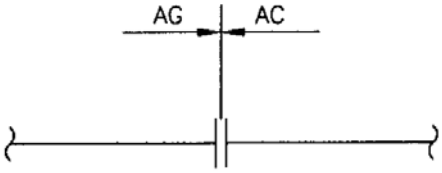
3.2.5.1 General

- Section 3.2.3.2 provides reference to required piping symbols for use on P&IDs.
- Clearly identify all lines entering and leaving the diagram, starting in order as follows:
    - Conveyed Fluid
    - Source / Destination
    - Drawing Number sheet and Zone
- Use the equipment number for the source or destination if the line is routed within the same process unit or system.

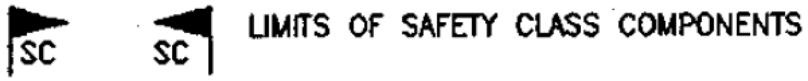
- For lines routed outside of the process unit's boundary, use a general name and associated equipment number for a source or destination.



- Clearly indicate where a line specification change occurs. This will be cause for a new line number. The example below shows a specification change at a flange where the specifications change. In the example below, the piping specifications are AG and AC.



- Identify underground lines with a specification break between AG (aboveground) and UG (underground) piping.
- Clearly indicate where a Limits of Safety Class (SC) Components and Limits of Safety Significant (SS)
- Components occur; see figure below. This will be cause for a new line number in the case of piping. Specific components of equipment and portions of instrumentation loops may require different classifications.



3.2.5.2 Utility and Auxiliary Lines on the P&ID

- Utility lines originate and terminate adjacent to the equipment involved.
    - Only the length of line necessary for valving, instrumentation, and line numbering is shown. Utility line origin and terminus is indicated by descriptive title only. Main utility headers are not shown on the unit P&ID; they are shown on the utility P&ID for that process area. Compressor utility piping is shown only when minor in scope. Otherwise, it is shown on a compressor auxiliary P&ID.

- Line size valves shown on the P&ID need not have their size indicated at the valve. Control and bypass valve sizes will always be shown.
- Reduction in line size is indicated for continuous drawn lines. Reducer symbols are not required for stub-ins.
- Each process line and each utility line is identified by a line number. Line numbers will appear on top of the horizontal line or to the left of the vertical line.
- Corrosion allowances other than the normal allowances indicated in the individual line classes will also be shown.
- Piping components not identified by Instrument or Mechanical Equipment Numbers, etc. and not covered by the Piping Material Specification, are identified by assigning an Item Code Number on the identification symbol. (Refer to the Legend Sheets).
- Packaged equipment or modules (vendor supplied) will be identified on the P&ID by a dashed line or cloud surrounding the package with arrows showing specific junctures of piping between the Contractor and the Supplier in a manner similar to spec break designations.
- Flange breaks will not be shown except for clarification, such as specification changes and at Supplier breaks, as required.
- Equipment, instruments, or piping, which are traced or jacketed, are so indicated.
- All notes will be placed under the horizontal process line or to the right of the vertical process line; for example, SLOPE, NNF (normally no flow), DO NOT POCKET, etc.
- High point vents and drains are shown only when they connect to a closed system or are required for process and safety reasons.
- All startup and shutdown lines will be shown.
- Pipe systems to be cleaned (such as pickled and sand blasted) will be identified (in Pipe specification document).
- Lines to be sloped will be identified with the slope symbol, as shown below:

SLOPED PIPE

3.2.5.3 Pump Piping

- When using a line size suction valve, the suction valve will be rated for pump discharge conditions when warm up bypasses are provided.
- Temporary pump suction screens may be installed at all centrifugal pumps before start-up and removed after preliminary operations. These screens will be located at the first flanged joint between the pump and the suction block valve with a spacer or breakout flange for easy removal. If a permanent screen or strainer is required, see to the Master Legend Sheets symbology; see Section 3.2.3.2.
- Provide permanent removable basket type strainers for all rotary pumps.
- Use a line size block and check valve in the discharge line (check valve will be located between block and pump).

- A standard pressure gauge connection will be located in the discharge piping between the pump nozzle and the check valve.
- Provide a casing vent and valve.

4.0 SOURCES

4.1 References

ISA-S5.1 Symbology

Process Industry Practices (PIP), PIP.org, Austin, Texas

H-6-l4982 Hanford Standard, General Symbology,

H-6-14983 Hanford Standard, Civil Symbology,

H-6-14984 Hanford Standard, Structural Symbology,

H-6-14985 Hanford Standard, Architectural Symbology,

H-6-14986 Hanford Standard, Machine Symbology,

H-6-14987 Hanford Standard, HVAC Symbology,

H-6-l 4988 Hanford Standard, Fire Protection Symbology,

H-6-14989 Hanford Standard, Control Systems Symbology,

H-6-14990 Hanford Standard, Electrical Symbology,

H-6-14991 Hanford Standard, Piping Symbology.

H-9-006010, Sheets 1 thru 6, Master PFD and P&ID Legend,

H-9-006015 Sheet 1, Master Abbreviations Legend Drawing,

H-9-006020, Sheet 1, Master Electrical and Elementary and One-Line Legend Drawing

H-9-006021, Sheet 1, Master Electrical Plan Symbology Drawing

HNF-64101 Preparation and CAD Data File Standards for Engineering Drawings

HNF-64102, Preparation and CAD Data File Standards for Legacy Engineering Drawings

MSC-PRO-ENG-709, CAD and Drawing Development and Control Process for Engineering Drawings

HNF-14660 Offsite Subcontractor Instructions for Preparation and Control of Engineering Drawings

Appendix A. Figures

Figure A-1, Process Flow Diagram Example

Figure A-2, Piping and Instrumentation Diagram Example

Figure A-1. Process Flow Diagram Example

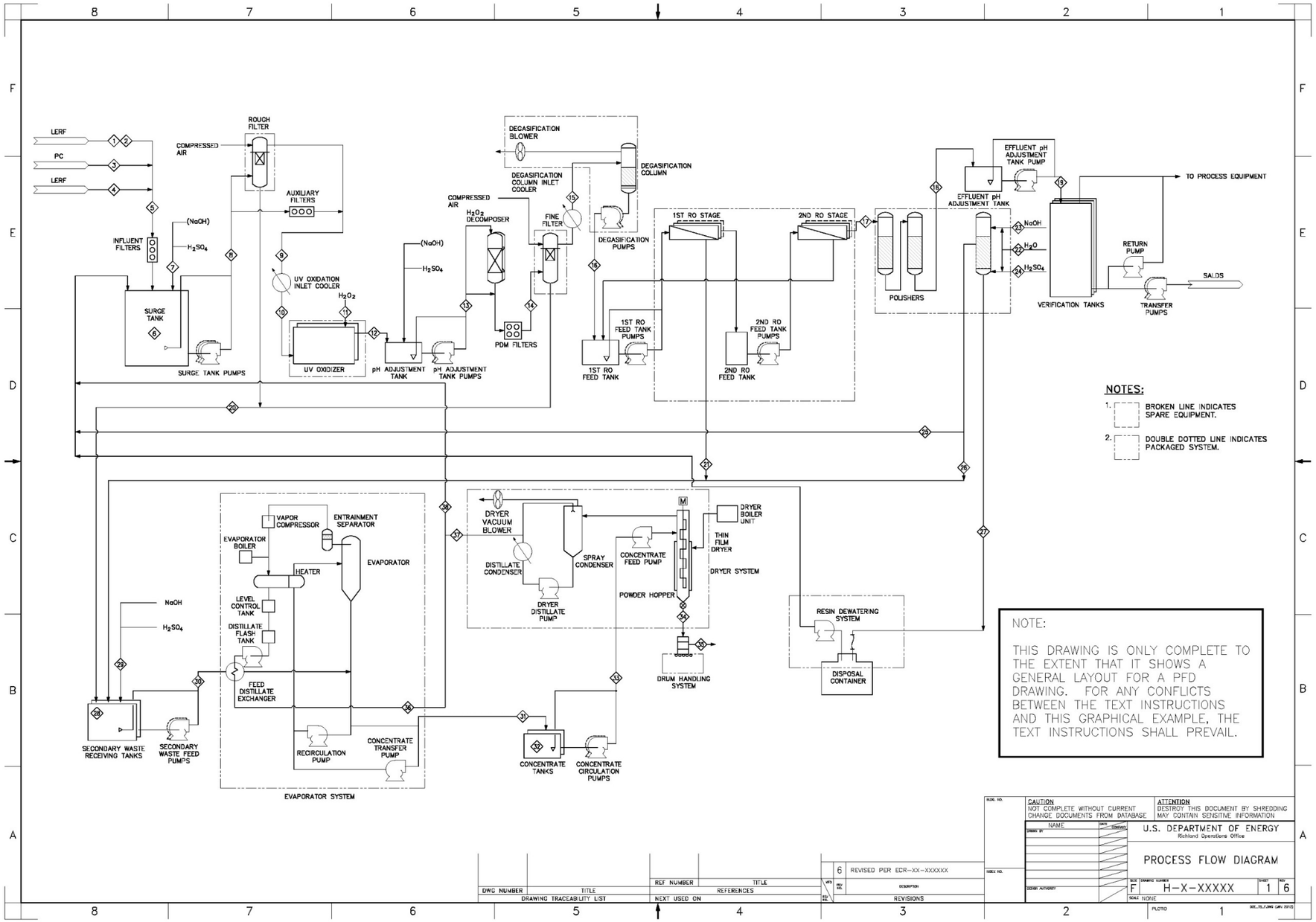


Figure A-2. Piping and Instrumentation Diagram Example