PROCESS INDUSTRY PRACTICES

January 2018

P&ID

PIP PIE001
Process Flow Diagram Documentation Guidelines

PURPOSE AND USE OF PROCESS INDUSTRY PRACTICES

In an effort to minimize the cost of process industry facilities, this Practice has been prepared from the technical requirements in the existing standards of major industrial users, contractors, or standards organizations. By harmonizing these technical requirements into a single set of Practices, administrative, application, and engineering costs to both the purchaser and the manufacturer should be reduced. While this Practice 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 Practice. Determinations concerning fitness for purpose and particular matters or application of the Practice to particular project or engineering situations should not be made solely on information contained in these materials. The use of trade names from time to time should not be viewed as an expression of preference but rather recognized as normal usage in the trade. Other brands having the same specifications are equally correct and may be substituted for those named. All Practices or guidelines are intended to be consistent with applicable laws and regulations including OSHA requirements. To the extent these Practices or guidelines should conflict with OSHA or other applicable laws or regulations, such laws or regulations must be followed. Consult an appropriate professional before applying or acting on any material contained in or suggested by the Practice.

This Practice is subject to revision at any time.

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1. Scope

This Practice provides general guidelines for the format and content of Process Flow Diagrams (PFDs) for process and utility systems.

This Practice covers the development of new PFDs and does not apply to existing PFDs developed before the adoption of this Practice.

The Practice applies to all diagrams that fit the definition of a PFD in Section 3.

This Practice can be applied to any CAD system used for developing PFDs and is not vendor, hardware, or software specific.

Although this Practice provides general guidelines for the development of PFDs, individual applications may require differing approaches than those recommended in this Practice. Determinations concerning fitness for purpose and matters of application of the Practice to a particular project or engineering situation should not be made solely on the information contained in this Practice.

Example PFDs in the Appendixes of this Practice are not intended to recommend specific design details or requirements, but are included to provide illustrations of various options available to the user.

2. References

Applicable parts of the following PIP Practice should be considered an integral part of this Practice. The edition in effect on the date of contract award should be used, except as otherwise noted. Short titles are used herein where appropriate.

Process Industry Practices (PIP)

- PIP PIC001 - *Piping and Instrumentation Diagram Documentation Criteria*

3. Definitions

anchor point: Operating conditions critical to the process performance which are required in order to achieve the desired processing objective (e.g., distillation column overhead pressure and temperature)

block flow diagram: Simplified PFD showing process steps (e.g., unit representation or batch processes within one vessel or unit) but not necessarily using symbology for equipment

heat and material balance (H&MB): Tabulation of the composition, flow, temperature, pressure and applicable physical properties (e.g., enthalpy, density, viscosity) of every major stream shown on a PFD. H&MB may also be known as mass and energy balance

heat exchanger duty table: Listing of heat transfer loads

nameplate capacity: Nominal capacity of a production unit based on the stream factor over a given period of time

operating conditions: Set of stream properties for manufacture of a particular product

plant: Location of an operating unit depicted by one or more PFDs

*process***:** Equipment configuration and operating conditions for manufacturing of one or more products

process flow diagram (PFD): Simplified schematic showing process information of a facility. Process flow diagrams are pictorial representations of the equipment and flow streams that correspond to the normal operating conditions and equipment configuration required to meet nameplate capacity of the unit. PFDs may be as simple as a block flow diagram or may be a complex set of drawings that includes equipment sizes and design criteria.

stream factor: Percentage of the year the unit has to operate at PFD feed rate to meet nameplate capacity (e.g., If a unit operates at half feed rate for 96 hours after a catalyst change, only 48 hours are counted towards the stream factor). Also may be known as operating factor.

stream number: Number used to identify a process or utility stream on a PFD and associated H&MB

stream table: An abbreviated heat and material balance table

4. General Considerations

4.1 A process flow diagram with associated H&MBs provides the following information:

a. Definition of the process equipment and the connectivity between unit operations

b. Illustration of the flow path of main process and utility streams

c. List of operating conditions and critical physical property data

d. Illustration of the basic control schemes for systems critical to plant operation

e. Provision of sufficient process data to initiate and validate engineering design

4.2 Consistent units of measure should be used throughout a PFD and associated H&MBs.

4.3 A H&MB can only document a single set of operating conditions; however, actual operation typically occurs over a range of conditions. If a unit is designed to operate with significantly different conditions in the same equipment configuration, a set of H&MBs should be prepared for each design case.

4.4 A PFD should be prepared for each process. If a unit is designed to operate in multiple configurations or make different products, a PFD may be required for each.

4.5 The intended use of a PFD determines the level of detail shown. (i.e., A PFD for project evaluation can be different from a PFD for detailed project design.)

On new or existing documents, new and existing components should be differentiated from each other by a cloud, a line weight or a line style.

Note: Reference *PIP PIC001* for additional details

5. Uses for PFDs

PFDs may be used for the following purposes:

a. Document and communicate the design of a process

b. Conduct design reviews

c. Optimize a design

d. Develop an accurate project scope

e. Develop equipment lists

f. Provide basis for material selection diagrams

g. Develop Piping and Instrumentation Diagrams (P&ID)

h. Develop written specifications

i. Drive detailed design activities

j. Aid in documenting environmental emissions data

k. Facilitate early safety reviews

Comment: Safety systems may be shown on a PFD based on project requirements, but if they create too much drawing complexity then a separate safety flow diagram should be developed.

l. Aid in documenting necessary PSM (process safety management) and PSI (process safety information) information

m. Prepare preliminary cost estimates

n. Train engineers, operators, and maintenance personnel

o. Troubleshoot process problems

6. Document Control

6.1 PFDs may contain confidential and proprietary information. Distribution of PFDs should be controlled to minimize the potential loss of sensitive information.

6.2 PFDs may be subject to US export controls. Legal counsel should be consulted before distributing PFDs to foreign nationals both inside and outside of the USA. An example of a typical export compliance statement for a PFD is as follows:

> THIS DOCUMENT CONTAINS TECHNICAL INFORMATION THAT IS SUBJECT TO U.S. EXPORT CONTROL REGULATIONS. IT MAY NOT BE EXPORTED OR RE-EXPORTED EXCEPT AS AUTHORIZED UNDER APPLICABLE U.S. EXPORT CONTROL REQUIREMENTS.

6.3 Distribution of PFDs to suppliers and contractors should only be made after appropriate non-disclosure agreements have been executed. An example of a typical confidentiality statement for a PFD is as follows:

> THIS DOCUMENT CONTAINS INFORMATION WHICH IS PROPRIETARY TO *(company name)*. THIS INFORMATION IS TO BE HELD IN CONFIDENCE. NO DISCLOSURE OR OTHER USE OF THIS DOCUMENT, EXCEPT AS NECESSARY FOR OPERATION OF THE PLANT WITHIN OWNER'S CONTRACTUAL OBLIGATIONS IS TO BE MADE WITHOUT PRIOR WRITTEN CONSENT OF (*company name)*.

7. PFD Drawing Layout

7.1 See Appendix B for examples of different layouts and levels of complexity for PFDs.

7.2 Title block should be at the bottom right corner.

7.3 A revision history and approval block should be included.

7.4 If a stream table or H&MB is shown, it should be located at the bottom, starting from the left margin.

7.5 If nameplate capacity information is shown, it should be located prominently, near or in the title block.

7.6 Notes should be located at the bottom or right side.

7.7 If a heat exchanger duty table is shown, it should be located to the right of the stream table.

7.8 If a batch sequence table is shown, it should be located to the right of the stream table.

7.9 Process flow should be shown from left to right. Exceptions may be made if it makes the PFD easier to understand (e.g., recycle lines). Lines should not be shown entering or leaving from the top or bottom.

8. PFD Content

8.1 Legend Sheets

See Appendix A for symbology and nomenclature for use on PFDs. Additional symbols may be included to address industry specific needs.

8.2 Title Block

A title block should contain the following minimum information:

a. The drawing title, “Process Flow Diagram”

b. Area or unit number or description

c. Descriptive title for the process or section shown

d. Drawing number and revision

8.3 Nameplate Capacity Basis

A PFD should document the nameplate capacity of the process. Each company will need to determine what basis they will use for this calculation. Suggested calculation methods follow:

8.3.1 For continuous processes, the days of operation per year at PFD rate should be shown. This may be expressed as a percent by dividing the days of operation per year by 365 calendar days per year.

8.3.2 For batch processes, the number of batches per day should be shown with the stream factor.

8.3.3 For operating units that can produce different products calculate the nameplate capacity assuming the unit makes one product for the entire year with the highest system demands or calculate the capacity based on the design product slate considering required unit switches.

8.3.4 For operating units that can produce different products, the number of days of lost production each time the unit switches from one product to another should be shown.

8.3.5 Design utilization or feedstock conversion efficiency should be shown.

8.4 H&MB/Stream Table and Process Conditions

8.4.1 H&MB(s) should be developed. It may be a companion document to a PFD or it may be shown on a PFD.

8.4.2 All PFDs for a project should be consistent in presentation of operating conditions.

8.4.3 The process stream operating conditions may be tabulated separately from a PFD. If the process stream design conditions are tabulated separately, a reference to the associated H&MB may be included on the PFD.

8.4.4 Preferably, an H&MB should be developed using a spreadsheet or material balance software that can be imported into the PFD. Typically, drafting and simulation software can be linked to provide automatic updating.

8.4.5 Each stream should be identified by a unique number. The number should be placed in a diamond on or in the process line and at the top of the stream information on the H&MB/stream table. Utility lines may also be identified in this way.

8.4.6 Operating conditions critical to process performance may be shown as an anchor point on the PFD. This designation should be used with discretion because it affects detailed engineering significantly.

8.4.7 In the left-most column of the table, all the major stream components used in the process should be listed, followed by physical/thermal properties. It is acceptable to list minor components with one or more major components or in a pseudo-component (e.g.: "low boilers" or "high boilers" or "C6+"). For examples, see Appendix B.

8.4.8 For a stream table, all the components need not be shown on every PFD sheet. Components introduced in later PFD sheets need not be listed on the prior sheets. Conversely, components that are removed from the process on a prior sheet need not be listed on the later sheets.

8.4.9 As a minimum, for each stream the following values should be shown with the appropriate units:

a. Mass, molar, or volumetric flow of each component

b. Total flow

c. State (i.e., gas: g, liquid: l, solid: s, mixed: g/l/s)

d. Temperature and pressure (required for gases; optional for liquids and solids)

8.4.10 Other pertinent information may be shown in the H&MB/stream table. The information may include the components in weight percent, maximum flow for certain streams, and other physical and thermal properties (e.g., density, viscosity, stream enthalpy, particle size) needed to adequately define the material and conditions of the process.

8.4.11 For a batch process, the components and total flows should be shown as mass per batch and with the design feed rates. Batch information may be shown on the H&MB/stream table or on an additional batch sequence table listing all the steps and the requirements for each step. This information may be a separate document that is referenced by a note on each PFD.

8.4.12 For a batch process within a continuous process, the streams included in the batch part of the process should be shown twice: first as the average flow rate; and second as the actual design batch flow rates.

8.5 Heat Exchanger Duty

8.5.1 Heat exchanger duties should be developed and may be included on a PFD. The data should include the heat transferred by the process and the utility information (e.g., type, amount, inlet/outlet conditions).

8.5.2 For electrical heaters, power consumption should be shown.

8.5.3 For fired process heaters, the total fuel gas flow should be shown. If a fired heater is used to heat more than one process stream, the duty for each stream should be shown separately.

8.6 Utility Information

8.6.1 Utility requirements (e.g., cooling water, air, steam) should be developed and may be shown either on a PFD or as a companion document (e.g., utility summary). This data should include flow, temperature, pressure, etc.

8.6.2 The maximum cooling water operating temperature (i.e., summer) and flow to the exchangers should be shown.

8.6.3 Steam or fuel to turbine driven pumps or compressors and power usage for electric motors may be shown.

8.7 Process Equipment

8.7.1 Number of pieces of equipment shown on a PFD should be limited to make sure that all the information is clear.

8.7.2 Each piece of equipment should be identified with a unique tag number located near the equipment.

8.7.3 Equipment tag number and name should be shown along the top of a PFD and aligned above the equipment, if possible.

8.7.4 Appendix C lists the additional information that may be included with the equipment tag number and name on a PFD for various types of equipment. Equipment not listed should be described as appropriate to convey important data.

8.7.5 See Appendix A for equipment symbols that may be used. More detailed symbols from *PIP PIC001* may also be used.

8.7.6 Duplicated equipment (e.g., pumps) may be shown by a single symbol, showing all equipment tag numbers next to the symbol.

8.7.7 Trayed columns should show as a minimum the top, feed, side draw, and bottom trays. Alternate feed tray locations may also be shown with a clarifying note. Tray numbers should be shown on each of the trays shown. Typically, trays are numbered starting at the top of the column. This method is in accordance with the numbering convention used by many simulation programs.

8.7.8 Packed columns should show the number of packing sections.

8.7.9 Packaged systems (e.g., refrigeration units) may be shown as a box. Key sizing information should be listed similar to individual equipment. A vendor drawing may be referenced in the box.

8.8 Process Conditions

8.8.1 Process conditions may be shown for selected streams or equipment to facilitate process understanding. A process value may be inserted within a symbol attached to the stream or equipment. For examples, see Appendix B.

8.8.2 Distillation columns may show the top pressure, temperature, and reflux rate (as a flow or ratio). For columns with a vapor product and an external liquid reflux, the reflux line should be assigned a stream number and included in the H&MB/stream table.

8.8.3 For heat exchangers, the inlet and outlet temperatures with state should be shown on the PFD or the H&MB/stream table.

8.9 Process and Utility Lines

8.9.1 Major process streams should be shown.

8.9.2 Significant alternate flow paths (e.g., startup, shutdown, recycle) may be shown with a clarifying note.

8.9.3 Auxiliary piping and pump recirculation lines should not be shown.

8.9.4 Process streams entering or leaving a PFD should be shown by an off-page or off-plot connector indicating the service description and source or destination of the stream, including equipment name, equipment tag number, and PFD number. If no PFD exists for a utility stream, use utility connector symbol shown in Appendix A-1.

8.9.5 Utility stream lines should originate and end near the equipment shown instead of at the edge of a PFD. Utility streams should not be shown as manifolded with the same utility going to other equipment.

8.10 Instrumentation and Controls

8.10.1 PFDs are only intended to give an overview of the process control philosophy. Only major primary instrumentation for the process should be shown. Instrumentation details should not be shown.

8.10.2 Control loops should be shown by an instrument bubble connected by a solid line to the process/utility line or equipment to show the measuring point, and a second dashed line to the control element (i.e., valve or other control device) on the process line or utility line. Minor control loops should not be shown.

8.10.3 Monitoring instrumentation should be shown by an instrument bubble connected by a solid line to the process/utility line or equipment to show the measuring point.

8.10.4 Instrument bubble labels should be shown identifying function only (e.g. FC, LC, TI, and AI). Instrument tag numbers should not be shown.

9. Drafting Guidelines

Comment: The drafting guidelines presented in this section are recommended as optimal; however, deviations may be required because of CAD system configuration or standards. The guidelines are a simplified version of drafting guidelines provided in *PIP PIC001*.

9.1 Drawing Size

PFD drawing size should be ANSI D size, 22 inches by 34 inches. If reduced to 11 inches by 17 inches, the document should still be legible.

9.2 Text

9.2.1 Many variables may adversely affect text legibility (e.g., font availability and plotter/printer limitations). Text heights are recommended as optimal, and slight deviation, although not encouraged, may be required for legibility.

9.2.2 Text Arrangement

9.2.2.1 Text should be shown horizontally if possible.

9.2.2.2 Vertically oriented text should be read from bottom to top.

9.2.3 Drawing Notes

9.2.3.1 General text and drawing notes should be shown using a text height of 0.1 inch at a weight of 0.010 inch (0.25 mm).

9.2.3.2 General text and drawing notes should be aligned left and start in the upper-left corner of the notes area in accordance with Appendix B.

9.2.3.3 If a note contains more than one line, the line spacing should be 0.05 inch between each line.

9.2.3.4 Spacing between notes should be 0.25 inch beneath the last line of the preceding note maintaining a top and left text justification.

9.3 Equipment

9.3.1 Equipment outlines should be shown in accordance with Appendix A at a weight of 0.020 inch (0.5 mm).

9.3.2 Equipment tag numbers should use a text height of 0.16 inch at a weight of 0.014 inch (0.35 mm). Equipment tag numbers should be underlined.

9.3.3 Equipment internals should be shown using a short dashed line at a weight of 0.010 inch (0.25 mm). Vessel internals should be shown only if they affect the hydraulics or nozzle location.

9.3.4 Equipment Descriptive Labels

9.3.4.1 All equipment should have associated equipment descriptive labels (i.e., equipment numbers and descriptions) shown along the top of a PFD and aligned above the equipment, if possible. Alternatively, if a stream table is not included on a PFD, rotating equipment may have associated equipment descriptive labels shown on the bottom of the PFD.

9.3.4.2 Equipment descriptive labels should be located 0.25 inches minimum from the top or bottom border.

9.3.4.3 Equipment tag numbers should use a text height of 0.16 inch at a weight of 0.014 inch (0.35 mm) and be underlined.

9.3.4.4 Equipment data should use a text height of 0.1 inch at a weight of 0.014 inch (0.35 mm).

9.3.4.5 Equipment tag numbers should be top aligned, and each line of the data center justified.

9.4 Process, Utility and Instrument Lines

9.4.1 All lines should be spaced 0.5 inch minimum from each other on the full size drawing grid.

9.4.2 Process and instrumentation lines should be routed as directly as possible in vertical and horizontal orientation with minimal changes in direction. Showing lines in non-vertical and non-horizontal routing should be avoided.

9.4.3 Lines should not be routed across equipment and text.

9.4.4 Flow arrows should be shown at direction changes, pipe intersections, and equipment entrances.

9.4.5 Control valves should be shown in the horizontal position if possible.

9.4.6 Line Weights

9.4.6.1 Different line weights should be used to differentiate between primary process streams and secondary streams.

9.4.6.2 Primary process lines should be shown as solid lines at a weight of 0.028 inch (0.70 mm).

9.4.6.3 Secondary process and utility lines should be shown as solid lines at a weight of 0.014 inch (0.35 mm).

9.4.6.4 Instrument lines should be shown as dashed lines at a weight of 0.01 inch (0.25 mm).

9.4.7 Line Breaks

9.4.7.1 Vertical lines should break for horizontal lines.

9.4.7.2 Secondary lines should break for primary lines.

9.4.7.3 Instrument signal lines should break for process and utility lines.

9.4.7.4 Line break gaps should be maintained at 0.13 inch.

9.5 Drawing Connectors

9.5.1 Off-page and off-plot connectors for process and instrumentation lines should be shown entering a PFD horizontally 0.25 inch from the left inside borderline, and exiting 0.25 inch horizontally from the right inside borderline.

9.5.2 For drawing connectors for each line entering or leaving a PFD, the following data should be located as follows for both process streams and instrument loops:

a. The drawing number of the connected drawing should be shown inside a connector.

b. The service description should be shown above a connector and should contain the general stream name (e.g., cracked gas) or line description (e.g., reactor feed, tower overhead)

c. The description or equipment tag number of where the stream is coming from or going to should be shown below a drawing connector.

9.5.3 Text associated with off-page and off-plot connectors should be left justified.

Appendixes Summary

The Appendixes of this Practice contain tables of commonly used symbols, abbreviations and other identifiers; example PFDs; and suggested data for equipment types.

Appendix A contains symbols and text organized into legend sheets. Legend sheets are also commonly referred to as lead sheets or cover sheets.

Appendix B contains example PFDs that illustrate the text and utilize the symbols and legends on the legend sheets.

Appendix C contains suggested data that may be listed on PFD labels for the different equipment classes. This list is taken from Section 4.3 of *PIP PIC001* – Piping and Instrumentation Diagram Documentation Criteria.

Comment: The legend sheets and PFDs are drawn as standard, D-size (22 inches x 34 inches) drawings, but reduced to standard 8-1/2 inch x 11-inch pages for electronic distribution purposes. It is recommended that the legend sheets and PFDs be printed on 11-inch x 17-inch pages.

Appendix A – Legend Sheets

A-1: Symbols and Nomenclature – Typical Piping & Abbreviations

A-2: Symbols and Nomenclature – Typical Equipment

GENERAL ABBREVIATIONS

ATM	ATMOSPHERE
AP	ANCHOR POINT
BD	BLOW DOWN
BTMS	BOTTOMS
CAP	CAPACITY
CS	CARBON STEEL
DA	DEAERATED
DES	DESIGN
DIA	DIAMETER
DP	DESIGN PRESSURE or DIFFERENTIAL PRESSURE
DT	DESIGN TEMPERATURE
FV	FULL VACUUM
H&MB	HEAT AND MATERIAL BALANCE
HC	HYDROCARBON
HHP	HIGH HIGH PRESSURE
HP	HIGH PRESSURE or HORSEPOWER
ID	INSIDE DIAMETER
ISBL	INSIDE BATTERY LIMITS
KO	KNOCKOUT DRUM
LLP	LOW LOW PRESSURE
LP	LOW PRESSURE
M	MOTOR
MAX	MAXIMUM
MIN	MINIMUM
MP	MEDIUM PRESSURE
MW	MOLECULAR WEIGHT
NC	NORMALLY CLOSED
NNF	NORMALLY NO FLOW
NOM	NOMINAL
OSBL	OUTSIDE BATTERY LIMITS
OVHD	OVERHEAD
PFD	PROCESS FLOW DIAGRAM
PRESS	PRESSURE
REGEN	REGENERATION
SD	SHUTDOWN
SG	SPECIFIC GRAVITY
SP	SET POINT
SS	STAINLESS STEEL
TDH	TOTAL DIFFERENTIAL HEAD
TEMP	TEMPERATURE
T/T	TANGENT TO TANGENT
VAC	VACUUM
VB	VORTEX BREAKER

UTILITY ABBREVIATIONS

BBD	BOILER BLOWDOWN
BFW	BOILER FEED WATER
CHW	CHILLED WATER
CO2	CARBON DIOXIDE
COND	CONDENSATE
CW	COOLING WATER
DEMIN	DEMINERALIZED WATER
FG	FUEL GAS
FO	FUEL OIL
H2	HYDROGEN
HM	HEATING MEDIUM
IA	INSTRUMENT AIR
N2	NITROGEN
NG	NATURAL GAS
PA	PLANT AIR
PR	PROPANE REFRIGERANT
PW	PROCESS or PRODUCED WATER
REF	REFRIGERATION
RO	REVERSE OSMOSIS WATER
STM	STEAM
SW	SERVICE WATER or SOUR WATER

INSTRUMENT CODES

AC	ANALYZER CONTROLLER
AI	ONLINE ANALYZER
FC	FLOW CONTROLLER
FI	FLOW INDICATOR/METER
FRC	FLOW RATIO CONTROLLER
HC	HAND CONTROLLER (FROM CONTROL ROOM)
LC	LEVEL CONTROLLER
LI	LEVEL INDICATOR
PC	PRESSURE CONTROLLER
PDI	DIFFERENTIAL PRESSURE INDICATOR
PI	PRESSURE INDICATOR
SC	SPEED CONTROLLER
TC	TEMPERATURE CONTROLLER
TI	TEMPERATURE INDICATOR
WC	WEIGHT CONTROLLER

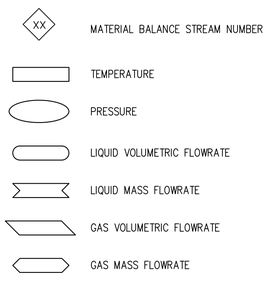
UNITS OF MEASURE (2)

ATM	ATMOSPHERES
BTU	BRITISH THERMAL UNITS
C	CELSUIS
CAL	CALORIES
cP	CENTIPOISE
F	FAHRENHEIT
FT3	CUBIC FEET
GPH	GALLONS PER HOUR
GPM	GALLONS PER MINUTE
HR	HOUR
HP	HORSEPOWER
LB	POUNDS
LPH	LITERS PER HOUR
LPM	LITERS PER MINUTE
KG	KILOGRAMS
KPa	KILOPASCALS
M3	CUBIC METERS
MIN	MINUTES
Pa	PASCALS
PSF	POUNDS PER SQUARE FOOT
PSI	POUNDS PER SQUARE INCH
SEC	SECONDS

PROCESS FLOW STREAM STATES

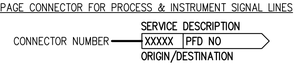
G	GAS
L	LIQUID
S	SOLID
V	VAPOR

PROCESS STREAM CONDITIONS

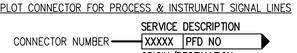


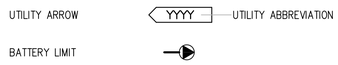
PIPING LINE SYMBOLS

OFF-PAGE CONNECTOR FOR PROCESS & INSTRUMENT SIGNAL LINES



OFF-PLOT CONNECTOR FOR PROCESS & INSTRUMENT SIGNAL LINES

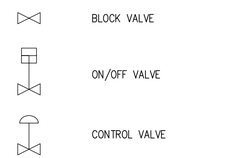




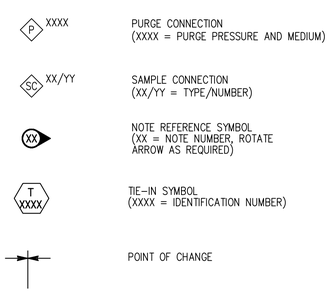
EQUIPMENT CLASSIFICATIONS (FROM TABLE 1 OF PIC001)

CLASS	SUBJECT	DESCRIPTION
A	MIXING EQUIPMENT	AGITATORS, AERATORS, MECHANICAL MIXERS, BLENDERS
B	BLOWERS	CENTRIFUGAL BLOWERS, POSITIVE DISPLACEMENT BLOWERS, FANS
C	COMPRESSORS	CENTRIFUGAL, RECIPROCATING, SCREW, VACUUM
D	MECHANICAL DRIVERS	ELECTRIC AND PNEUMATIC MOTORS, DIESEL ENGINES, STEAM AND GAS TURBINES
E	HEAT EXCHANGERS	UNFIRED HEAT EXCHANGERS, CONDENSERS, COOLERS, REBOILERS, VAPORIZERS AND HEATING COILS, DOUBLE PIPE, SPIRAL, PLATE & FRAME, AIR COOLERS, ELECTRIC HEATERS, PRINTED CIRCUITS, SCRAPED SURFACE HEAT EXCHANGERS
F	FIRED EQUIPMENT	FIRED HEATERS, FURNACES, BOILERS, KILNS
FL	FILTERS	BAG FILTERS, MICRON FILTERS, NANO FILTERS. MEMBRANE FILTERS VENT FILTERS, DEPTH FILTERS, VACUUM / NEUTSTSCH FILTERS, STERILE FILTERS
MH	MATERIAL HANDLING EQUIPMENT	CONVEYORS, DUST COLLECTORS, CYCLONES, ROTARY AIR LOCKS, SIFTERS
P	PUMPS	HORIZONTAL AND VERTICAL CENTRIFUGAL, POSITIVE DISPLACEMENT, VERTICAL CANNED, SCREW, GEAR, SUMP, PISTON, METERING, DIAPHRAGM
PE	PACKAGED EQUIPMENT	RO SKIDS, DI SKIDS, WATER SOFTENER SYSTEMS, REFRIGERATION SKIDS
R	REACTORS	
T	TOWERS/COLUMNS	
TK	TANKS	ATMOSPHERIC AND LOW PRESSURE TANKS, BINS, SILOS
U	MISCELLANEOUS EQUIPMENT	ANYTHING NOT SPECIFIED
V	VESSELS	SEPARATORS, DRIERS, ACCUMULATORS, DRUMS, JACKETED VESSELS

VALVE SYMBOLS



MISCELLANEOUS



NOTES:

1. FLOW ASSUMED LEFT TO RIGHT AS SHOWN.
2. EACH PROJECT OR DESIGN PACKAGE WILL NEED TO DEFINE WHICH SET OF UNITS OF MEASURE ARE TO BE USED.

PROCESS INDUSTRY PRACTICES
PROCESS FLOW DIAGRAM

SYMBOLS AND NOMENCLATURE
TYPICAL LEGEND SHEET
APPENDIX A-1

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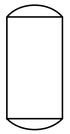
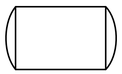
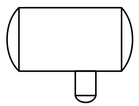
VESSELS & TANKS



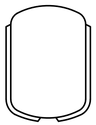
VERTICAL VESSEL



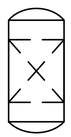
HORIZONTAL VESSEL



HORIZONTAL VESSEL
WITH SUMP/BOOT

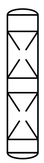


JACKETED PRESSURE VESSEL



REACTOR OR VESSEL
WITH PACKED BED

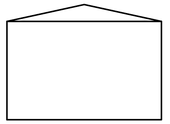
COLUMN



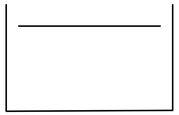
COLUMN – PACKED

TOWER/COLUMN

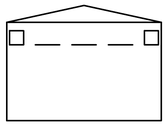
OPEN TANK



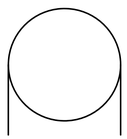
TANK



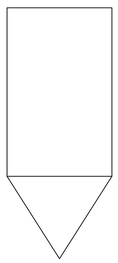
OPEN FLOATING ROOF
STORAGE TANK



INTERNAL FLOATING
ROOF TANK

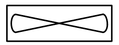


SPHERE



CONED BOTTOM
TANK/SILO

HEAT EXCHANGERS

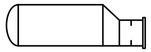


AIR COOLED EXCHANGER

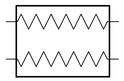
SHELL & TUBE EXCHANGER

COOLER

ELECTRIC HEATER



KETTLE



PLATE–FIN
EXCHANGER

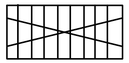
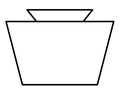
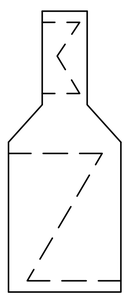


PLATE & FRAME
EXCHANGER

WASTE HEAT RECOVERY UNIT



COOLING TOWER



FIRED HEATER

PUMPS, COMPRESSORS & BLOWERS

PUMP

WELL PUMP

PROPORTIONING/METERING/
INJECTION PUMP

FAN/BLOWER

COMPRESSOR

EXPANDER/TURBINE

MISCELLANEOUS

STACK

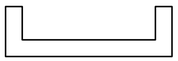
FLARE

AGITATOR

JET MIXER, EJECTOR,
EDUCTOR

FILTER/EXTRACTOR

PIG RECEIVER/LAUNCHER



SUMP/PIT

NOTES:

1.

PROCESS INDUSTRY PRACTICES
PROCESS FLOW DIAGRAM

EQUIPMENT SYMBOLS
TYPICAL LEGEND SHEET
APPENDIX A–2

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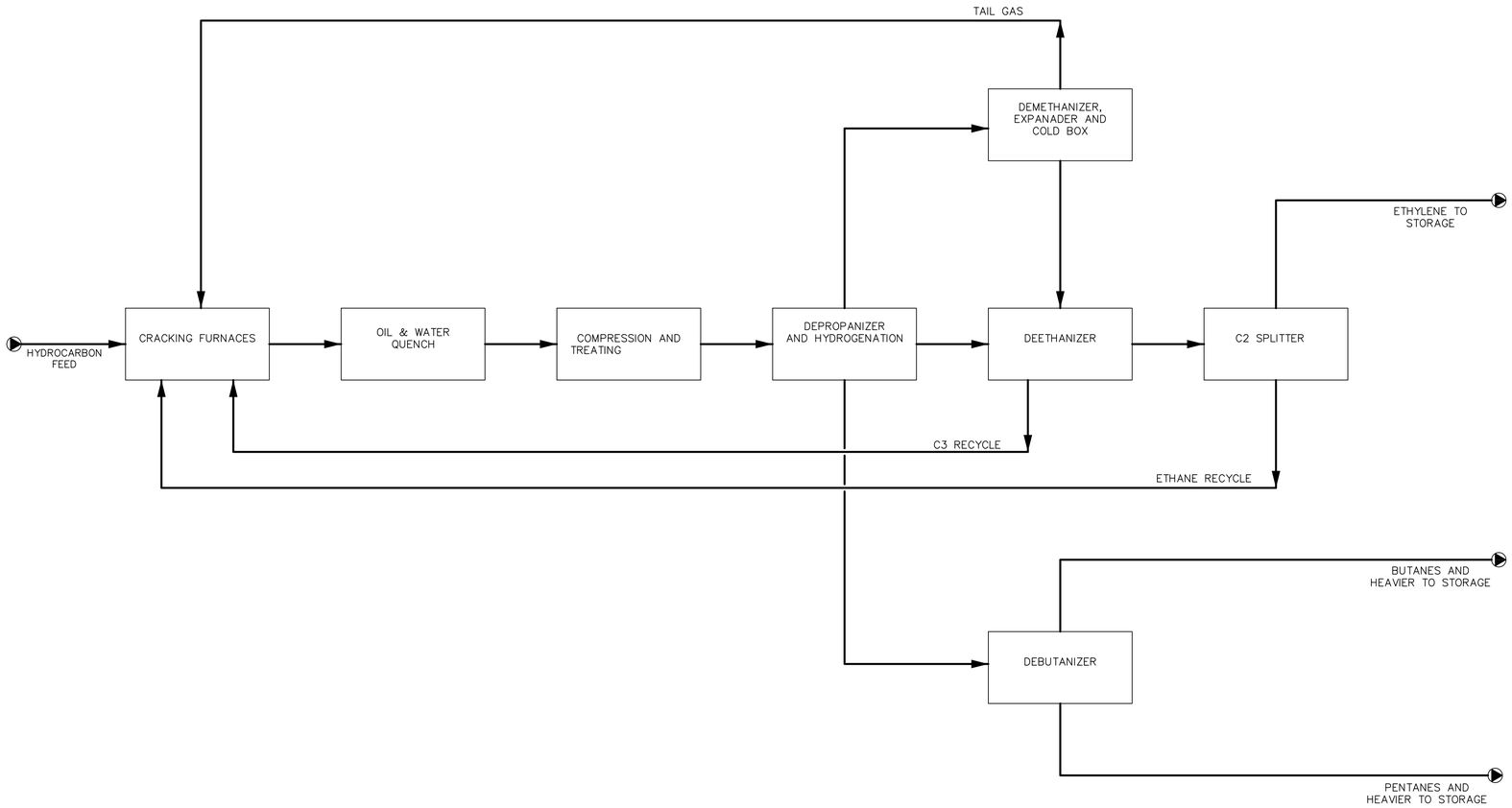
Appendix B – Example PFDs

B-1: Example PFD 1 – Block Flow Diagram

B-2: Example PFD 2 – Detailed Batch Process with H&MB

B-3: Example PFD 3 – Detailed Continuous Process with H&MB



PROCESS INDUSTRY PRACTICES
PROCESS FLOW DIAGRAM

EXAMPLE PFD 1
BLOCK FLOW DIAGRAM
APPENDIX B-1

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U–1002
INITIATOR CHARGE POT
MON. CAP. 10 GAL.
0'–9" I.D. x 3'–0" F/F
100 PSIG/FV AT 200°F
304 S.S.

R–1000
BATCH REACTOR
AGITATOR JACKETED VESSEL
NOM. CAP. 5000 GAL.
8'–0" DIA x 14'–0" OAL
180 SQ. FT. JACKET AREA
REACTOR DP : 150 PSIG AT 300 °F
JACKET DP : 100 PSIG AT 150 °F
REACTOR : INCONEL 600
JACKET : C.S.

A–1001
REACTOR AGITATOR
TURBINE
20 H.P.
INCONEL 600
SHAFT AND BLADE

T–1100
BATCH STILL ; TRAY TOWER
2'–6" ϕ x 65 FT T–F
30 SIEVE TRAYS
100 PSIG/FV AT 300°F
VESSEL : C.S.
TRAYS/INTERNALS : C.S.

U–1102
BATCH STILL POT
JACKETED VESSEL
5,000 GAL. NOM. CAP.
8'–0" ϕ x 10'–0" T/T
JACKETED AREA = 200 SQ FT
VESSEL DP = 100 PSIG/FV AT 350°F
JACKET DP = 100 PSIG AT 350°F
VESSEL : C.S.
JACKET : C.S.

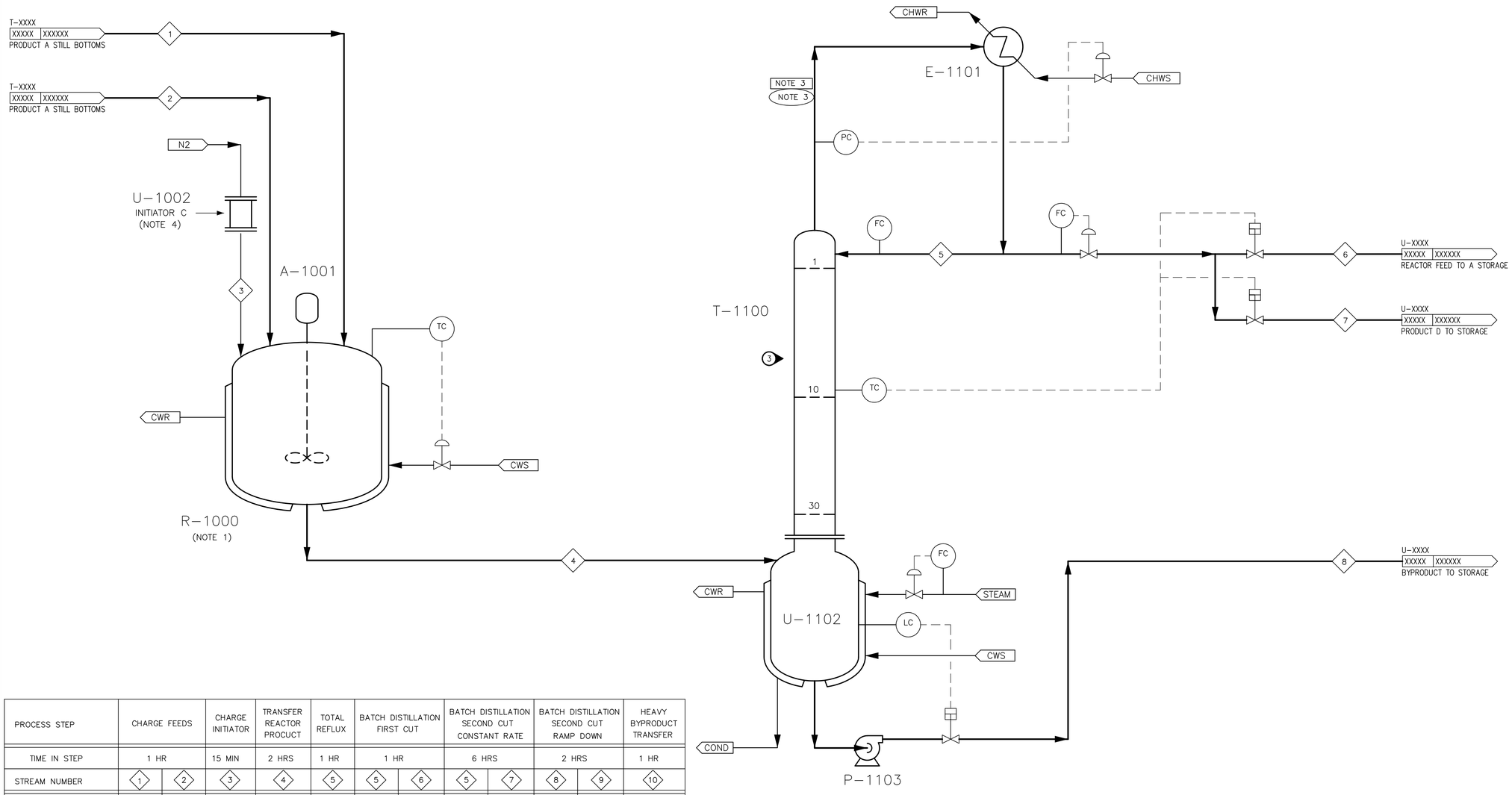
P–1103
BATCH STILL BOTTOM PUMP
MAG DRIVE CENTRIFUGAL
40 GPM AT 75 FT TDH
3 H.P.
CASING : D.I.
IMPELLER : 316 SS

E–1101
BATCH STILL CONDENSER
SHELL & TUBE (AEU), 1250 SQ. FT.
SHELL DP : 100 PSIG/FV AT 300°F
TUBE DP : 100 PSIG/FV AT 300°F
SHELL : C.S.
TUBE : C.S.

NOTES:

NAME PLATE : 18 MMLB/YR – PRODUCT D
STREAM FACTOR : 86% (2 BATCHES PER DAY)
UTILIZATION : 0.251 LB A/LBD
0.763 LB B/LBD

1. REACTIONS
   A + B ⟶ D
   MB ⟶ HEAVIES
   CONVERSION OF COMP B = 100%
2. DISTILLATE PRODUCT AND REFLUX SHOWN ARE AVERAGE FOR RAMP DOWN STEP. WHEN POT LEVEL IS BELOW 30%, STEAM RATE WILL REDUCE. MAINTAIN REFLUX RATIO BY ADJUSTING PRODUCT TAKE–OFF.
3. SEE BATCH SEQUENCE DOCUMENT FOR COMPLETE BATCH STEP DETAILS, INCLUDING OPERATING CONDITIONS. EXCHANGER DUTIES SHOWN ON EXCHANGER TABLE ARE EXCHANGER SIZING CALCULATION.
4. LOAD PRE–WEIGHED INITIATOR C TO CHARGE POT.



PROCESS STEP		CHARGE FEEDS		CHARGE INITIATOR	TRANSFER REACTOR PROCUCT	TOTAL REFLUX	BATCH DISTILLATION FIRST CUT		BATCH DISTILLATION SECOND CUT CONSTANT RATE		BATCH DISTILLATION SECOND CUT RAMP DOWN		HEAVY BYPRODUCT TRANSFER
TIME IN STEP		1 HR		15 MIN	2 HRS	1 HR	1 HR		6 HRS		2 HRS		1 HR
STREAM NUMBER		1	2	3	4	5	5	6	5	7	8	9	10
STREAM NAME		FEED A	FEED B	INITIATOR	REACTOR PRODUCT	BATCH STILL REFLUX	BATCH STILL REFLUX	COMP A RECYCLE	BATCH STILL REFLUX	PRODUCT D CUT	BATCH STILL REFLUX	PRODUCT D CUT	HEAVY BYPRODUCT
COMPONENT	M.W.												
COMP A	20	7,400			200		3,455	200					
COMP B	60		21,900										
COMP C	140			200	25								50
COMP D	80	350			14,575		6,045	350	9,500	4,000	4,750	2,350	100
HEAVIES	240				150								300
FLOW, LB/HR		7,750	21,900	200	14,950		9,500	550	9,500	4,000	4,750	2,350	450
TOTAL LB/BATCH		7,750	21,900	200	29,700	——	——	550	——	24,000	——	4,700	450
STATE		L	L	L	L	L	L	L	L	L	L	L	L
TEMPERATURE, °F		AMB	AMB	AMB	150	70	70	70	75	75	75	75	
PRESSURE, PSIG		55	55	55	50	25	25	25	15	15	15	15	80
DENSITY, LB/FT3		60.1	63.5	100.0	57.6	60.1	60.1	60.1	63.6	63.6	63.6	63.6	87.2

HEAT DUTIES (NOTE 3)			
EQUIP. NO.	DUTY BTU/HR	TYPE OF UTILITY	QUANTITY LB/HR
R–1000	1,200,000	COOLING WATER (90 F °TO 100 F) °	120,000
E–1101	1,900,000	CHILLED WATER (45 F °TO 55 F) °	190,000
U–1102	1,900,000	STEAM (35 PSIG)	2,000

PROCESS INDUSTRY PRACTICES
PROCESS FLOW DIAGRAM

EXAMPLE PFD 2
DETAILED BATCH FLOW DIAGRAM
APPENDIX B–2

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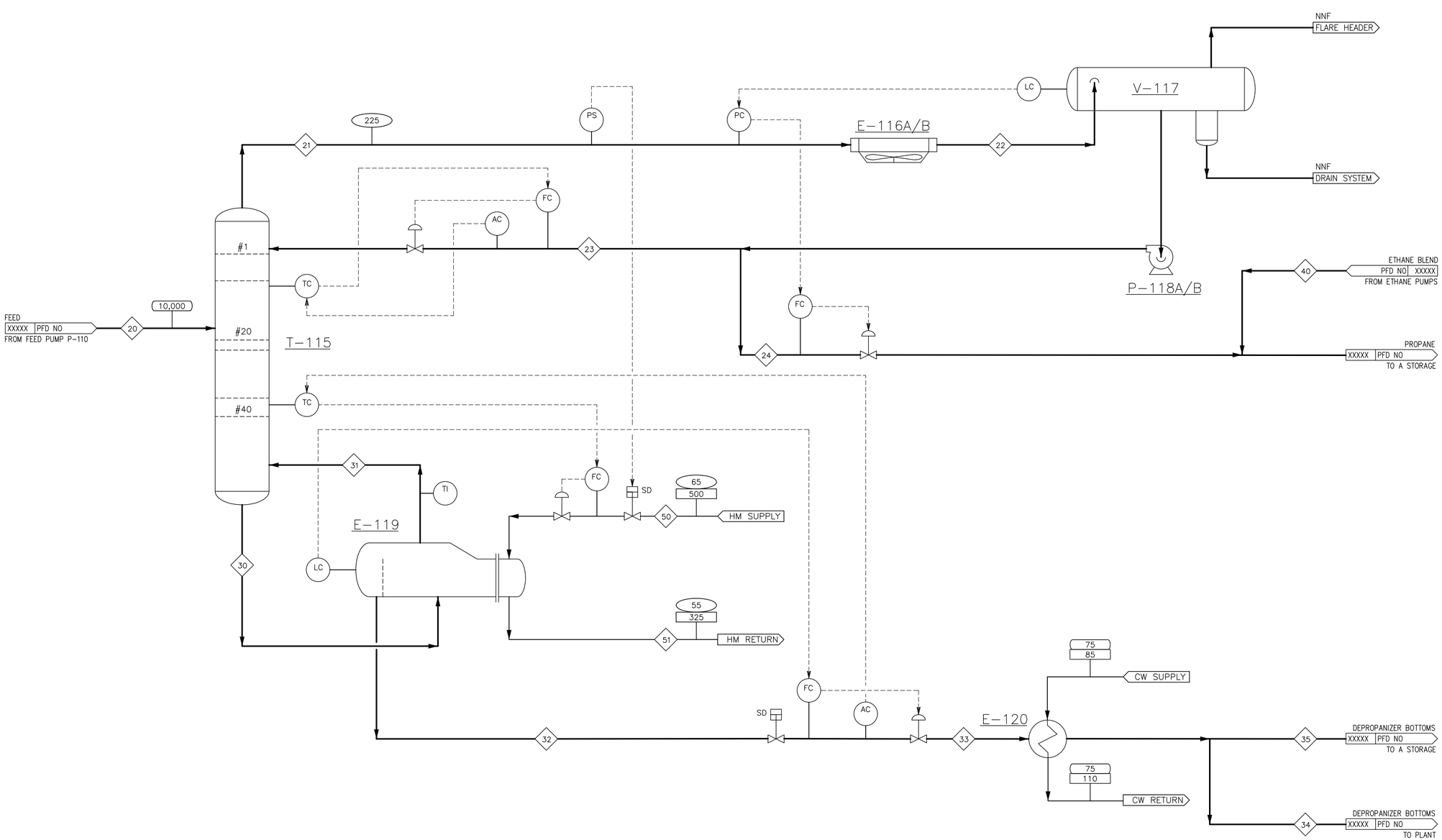
T-115	E-119	E-116A/B	E-120	V-117	P-118A/B
DEPROPANIZER	DEPROPANIZER REBOILER	DEPROPANIZER CONDENSER	BOTTOMS PRODUCT COOLER	DEPROPANIZER REFLUX DRUM	DEPROPANIZER REFLUX PUMP



NOTES:

1. REFER TO PIE001-B-003-2 FOR STREAM PROPERTIES.

LEGEND:

- STREAM NO.
- FLOW, GPM
- PRESSURE, PSIG
- TEMPERATURE, °F

PROCESS INDUSTRY PRACTICES
PROCESS FLOW DIAGRAM

EXAMPLE PFD
DETAILED CONTINUOUS FLOW DIAGRAM
APPENDIX B-3

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ISSUED: NOV 2017
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PAGE 1 **OF** 2
PIE001-B-003-1

[Company Name]
[Project Name]
[Location]

Heat & Material Balance

Capacity: [ ]
[Design Basis or Case]

Document Number: PIE001-B-003-2
Project Number: [ ]
Revision [ ] & [Date]

Stream Number		20	21	22	23	24	30	31	32	33	34	35	40	50	51
Stream Description		Depropanizer Feed	Depropanizer Overheads	Overhead Condenser Outlet	Reflux	Depropanizer Overhead Product	Bottoms to Reboiler	Vapor Return	Depropanizer Bottoms Product	Depropanizer Bottoms Product	Bottoms to Plant	Bottoms to Storage	Reactor 1R-2 Outlet	Hot Oil Supply	Hot Oil Return
Overall Properties															
Pressure, psig		250.0	225.0	225.0	225.0	225.0	235.0	235.0	235.0	220.0	215.0	215.0	300.0	65.0	55.0
Temperature, °F		100.0	118.7	116.8	116.8	116.8	213.0	219.0	219.0	213.4	150.0	150.0	100.0	500.0	325.0
Mass Flow, lb/hr		77,346	121,378	121,378	64,643	56,735	184,308	163,698	20,610	20,610	0	20,610	10	16,350	16,350
Mole Flow, lbmole/hr		1,635	2,756	2,756	1,468	1,288	3,153	2,806	347	347	0	347	0	-	-
Vapor Weight Fraction		0	1	0	0	0	0	1	0	0.041	0	0	1	0	0
Enthalpy Flow, MMBtu/hr		-81.56	-119.53	-134.79	-71.79	-63.00	-144.05	-110.24	-16.15	-16.15	0.00	-17.15	-0.01	-	-
Composition, mole%	*Mol Wt.*														
Methane	16.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	-	-
Ethane	30.1	1.00	1.27	1.27	1.27	1.27	0.00	0.00	0.00	0.00	0.00	0.00	95.00	-	-
Propene	42.1	2.00	2.54	2.54	2.54	2.54	0.00	0.01	0.00	0.00	0.00	0.00	0.00	-	-
Propane	44.1	75.00	94.92	94.92	94.92	94.92	1.78	1.88	1.01	1.01	1.01	1.01	4.00	-	-
i-Butane	58.1	8.00	1.00	1.00	1.00	1.00	38.61	39.17	34.01	34.01	34.01	34.01	0.00	-	-
n-Butane	58.1	5.00	0.04	0.04	0.04	0.04	22.89	22.83	23.43	23.43	23.43	23.43	0.00	-	-
1-Butene	56.1	2.00	0.10	0.10	0.10	0.10	9.70	9.77	9.05	9.05	9.05	9.05	0.00	-	-
i-Butene	56.1	2.00	0.13	0.13	0.13	0.13	9.78	9.88	8.96	8.96	8.96	8.96	0.00	-	-
tr2-Butene	56.1	1.00	0.01	0.01	0.01	0.01	4.61	4.60	4.69	4.69	4.69	4.69	0.00	-	-
cis2-Butene	56.1	1.00	0.00	0.00	0.00	0.00	4.43	4.40	4.70	4.70	4.70	4.70	0.00	-	-
n-Pentane	72.2	3.00	0.00	0.00	0.00	0.00	8.20	7.46	14.14	14.14	14.14	14.14	0.00	-	-

NOTE: Stream numbers refer to PIE001-B-003-1.

Appendix C – Suggested Equipment Data

The following content is taken from Section 4.3.3 of *PIP PIC001*. The following suggested information may be shown in detailed equipment labels on the PFD, if necessary.

4.3.3 Equipment Data

Units of measure (*e.g.*, GPM, PSIG, BTU/hr) for equipment data should be shown as required. Equipment not listed should be described as appropriate to convey important data.

4.3.3.1 Agitators, Mixers

- Equipment/Item Number
- Title/Service
- Power Requirements
- Materials of Construction

4.3.3.2 Blowers

- Equipment/Item Number
- Title/Service
- Capacity (Flow and D/P)
- Power Requirements
- Materials of Construction

4.3.3.3 Compressors

- Equipment/Item Number
- Title/Service
- Capacity (Flow and D/P)
- Power Requirements
- Materials of Construction

4.3.3.4 Heat Exchangers

- Equipment/Item Number
- Title/Service
- Duty
- Surface Area
- Shell Design Pressure @ Temperature
- Tube Design Pressure @ Temperature
- Materials of Construction (Shell/Tubes)

- Insulation

4.3.3.5 Fired Equipment

- Equipment/Item Number
- Title/Service
- Duty

4.3.3.6 Filters

- Equipment/Item Number
- Title/Service
- Size, Capacity
- Design Pressure @ Temperature
- Materials of Construction

4.3.3.7 Material Handling Equipment

- Equipment/Item Number
- Title/Service
- Size, Capacity
- Materials of Construction

4.3.3.8 Pumps

- Equipment/Item Number
- Title/Service
- Capacity (Flow and TDH)
- Power Requirements
- Materials of Construction
- Insulation/Tracing

4.3.3.9 Vessels/Tanks

- Equipment/Item Number
- Title/Service
- Size, Capacity
- Design Pressure @ Temperature
- Materials of Construction
- Insulation/Tracing