FORD, BACON & DAVIS
A Limited Liability Company

AIChE
The Global Home of Chemical Engineers

Art Of The P&ID

What Is A P&ID?

- **Piping And Instrument Diagram** (P&ID) Is A Schematic Diagram That Shows How Equipment And Instruments Connect To Form A Functional Process System

- The **P&ID** Is The **Chief Control Document** For The Engineering Design Of Petrochemical And Refinery Systems

Why Is A P&ID Important?

- Defines Scope
- Specifies Systems
- Identifies Essential **Components**
- Guides Engineering Design
- Tracks Changes
- Assists Construction
- Trains Operators
- Meets PSI Requirements

P&ID Components

Component	Function
Equipment	Convert
Instruments	Control
Pipe	Connect Convey

P&ID Components

- **Equipment** Is Shown With Symbols That Represent Different Types Of Equipment
  - Columns
  - Heat Exchangers
  - Pressure Vessels
  - Pumps
  - Tanks

P&ID Components

- **Instruments** Are Shown With Symbols That Represent Inline Or Attached Devices That Measure Or Control The Process
  - Analyzers
  - Control Valves
  - Flow Meters
  - Local Indicators
  - Software Elements
  - Transmitters

P&ID Components

- **Piping** Between Equipment Is Shown As Lines With Special Symbols For Piping Components
  - Expansion Joints
  - Insulation / Heat Tracing
  - Flanges
  - Reducers
  - Specialty Pipe Items
  - Valves

P&ID Components

- **Signals** Between Instruments Are Also Shown As Lines, Usually Dashed Or With Special Symbols
  - Hard Wired Links
  - Hydraulic Connections
  - Pneumatic Connections
  - Software Links

P&ID Development

- Locate The **ROAD MAP**
- Standardize On **FORMAT**
- **LAYOUT** For Clarity
- **ANALYZE** Content for Accuracy
- **AUDIT** For Completeness
- **CHECK** For Consistency

Locate The ROAD MAP

Locate The ROAD MAP

- Finalize P&ID Legends & Symbols Early
  - Use Client Standard If Available
  - Copy From Previous Client Project
  - Develop For New Project & Get Client Approval
- Use PIP PIC001 P&ID Documentation Criteria As Default
- Legends & Symbols Should Match CADD Drafting Symbology

Locate The ROAD MAP

- Use **P&ID Kickoff Meeting(s)** For Project Team Review And Consensus
  - P&ID Symbology / Layout
  - Execution Plan
  - Management Of Change
- Follow **P&ID Quality Assurance Matrix** And **P&ID Completeness Checklist** For Each Stage Of P&ID Development

P&ID Legends & Symbols

- Abbreviations
- Equipment Symbols
- Instrument Symbols
- Pipe Symbols
- Keys For Equipment, Instrument, & Pipe Numbering
- Standard Details

Abbreviations

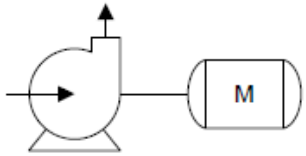
ABBREVIATIONS

ABS	ABSOLUTE
AG	ABOVE GROUND
ASB	ASBESTOS
ATM	ATMOSPHERE
AVG	AVERAGE
BL	BATTERY LIMIT
BYP	BYPASS
CL	CENTERLINE
CC	CHEMICAL CLEANOUT
COR	CORIOLIS
CSC	CAR SEAL CLOSED
CSO	CAR SEAL OPEN
CTR	CENTER
CONN	CONNECTION
CHWR	CHILLED WATER RETURN
CHWS	CHILLED WATER SUPPLY
CTWR	COOLING WATER RETURN
CTWS	COOLING WATER SUPPLY
DE	DEENERGIZE

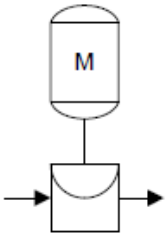
Equipment Symbols

PUMPS

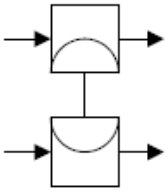
CENTRIFUGAL
(MOTOR DRIVEN)



DIAPHRAGM
(MOTOR DRIVEN)



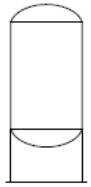
DOUBLE-DIAPHRAGM
(PNEUMATIC/HYDRAULIC
DRIVE)



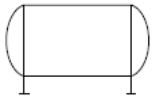
Equipment Symbols

VESSELS

VERTICAL VESSEL
(SKIRT MOUNTED)



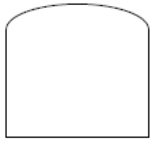
HORIZONTAL VESSEL
(LEG MOUNTED)



OPEN TOP

CONE ROOF

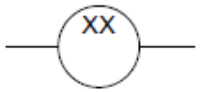
DOME ROOF



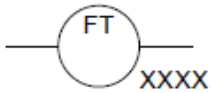
Instrument Symbols

PRIMARY ELEMENT SYMBOLS

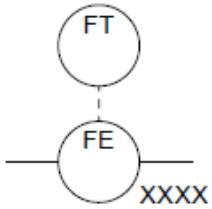
GENERAL IN-LINE ELEMENT
(XX = FSH, FSL, FG, FE, FT)



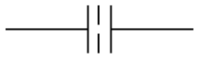
IN-LINE FLOWMETER W/
INTEGRAL TRANSMITTER
(XXXX = CORIOLIS,THERMAL,
ETC.)



IN-LINE FLOWMETER W/
SEPARATE TRANSMITTER
(CORIOLIS, ETC.)



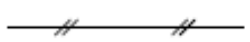
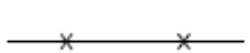
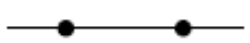
ORIFICE



MAGNETIC FLOWMETER

Instrument Symbols

4. SIGNAL LINES:

ELECTRIC	
SOFTWARE OR DATA	
PNEUMATIC	
HYDRAULIC	
CAPILLARY TUBE	
ELECTROMAGNETIC, SONIC, OPTICAL, or NUCLEAR	
MECHANICAL	

Pipe Symbols

PIPING FITTINGS

FLANGE 

WELD CAP 

CONCENTRIC REDUCER 

ECCENTRIC REDUCER 

UNION 

HOSE CONNECTION 

SPACER 

BLIND 

OPEN FIGURE 8 BLIND 

CLOSED FIGURE 8 BLIND 

Pipe Symbols

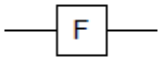
SPECIALTY ITEMS

DETONATION ARRESTOR

EXCESS FLOW VALVE
(XXX = FLOW LIMIT)

EXPANSION JOINT

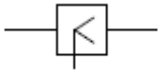
FILTER, TUBING TYPE



FLAME ARRESTOR

FLEX HOSE

INJECTION / SPRAY NOZZLE



IN-LINE (STATIC) MIXER

OPEN DRAIN

Pipe Symbols

VALVES

	NORMALLY OPEN	NORMALLY CLOSED
BALL VALVE		
BUTTERFLY VALVE		 NC
CHECK VALVE (SWING, LIFT, ETC.)		
CHECK VALVE (SPRING LOADED)	 XXX	

(XXX = CRACKING PRESSURE IN PSIG)

DIAPHRAGM VALVE		
GATE VALVE		
GLOBE VALVE		
KNIFE VALVE		 NC

Component Numbering

- Tag Numbers For **Equipment**
  - Letter Code For Equipment Type
  - Number For Specific Identification

Equipment Numbering

Function	Type
Exchange Heat	CT = Cooling Tower FH = Fired Heater HE = Heat Exchanger (Shell & Tube) RU = Refrigeration Unit
Move Fluid	K = Blower/Fan/Compressor EJ= Eductor/Ejector P = Pump
React Components	FL = Flare RX = Reactor (Catalyst Bed, Furnace)
Separate Components	C = Column F = Filter
Store Fluid	D = Drum TK = Tank

Component Numbering

- Loop Numbers For **Instruments** (ISA Typical)
  - Letter Code For Instrument Function
  - Letter Code For Instrument Type
  - Number For Specific Identification

Instrument Numbering

Function	Type
A = Analyze	C = Controller
F = Flow	E = Element
L = Level	I = Indicator
P = Pressure	T = Transmitter
T = Temperature	V = Valve

Component Numbering

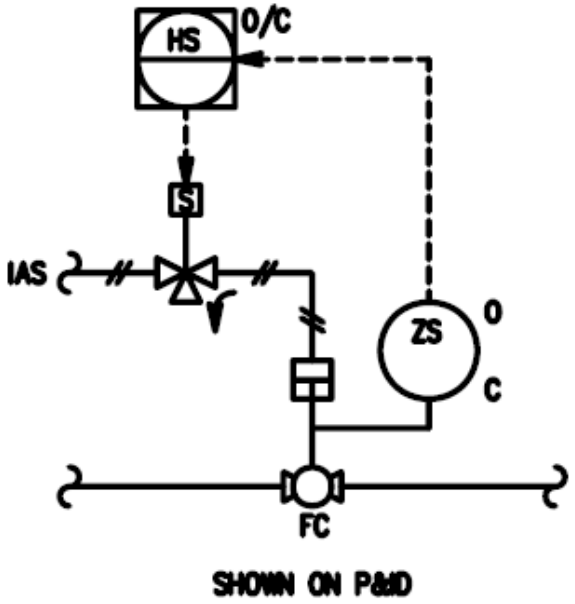
- Line Numbers For **Piping**
  - Pipe Size
  - Process Or Utility Service Code
  - Number For Specific Identification
  - Pipe Specification
  - Insulation Type
  - Insulation Thickness
  - Heat Tracing Requirement

Component Numbering

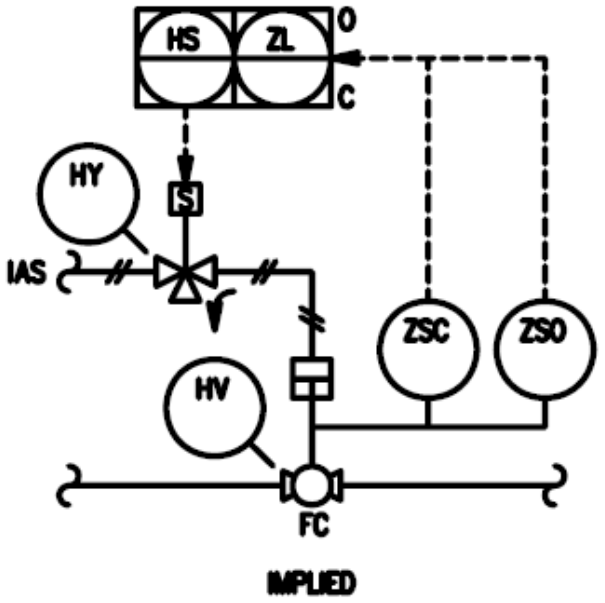
- Specialty Item Numbers For Special Pipe Components Not Addressed In Pipe Specifications
- Tie Point Numbers
- Sample Connection Numbers
- Valve Specification Numbers

Standard Details

TYPICAL VALVE DETAIL



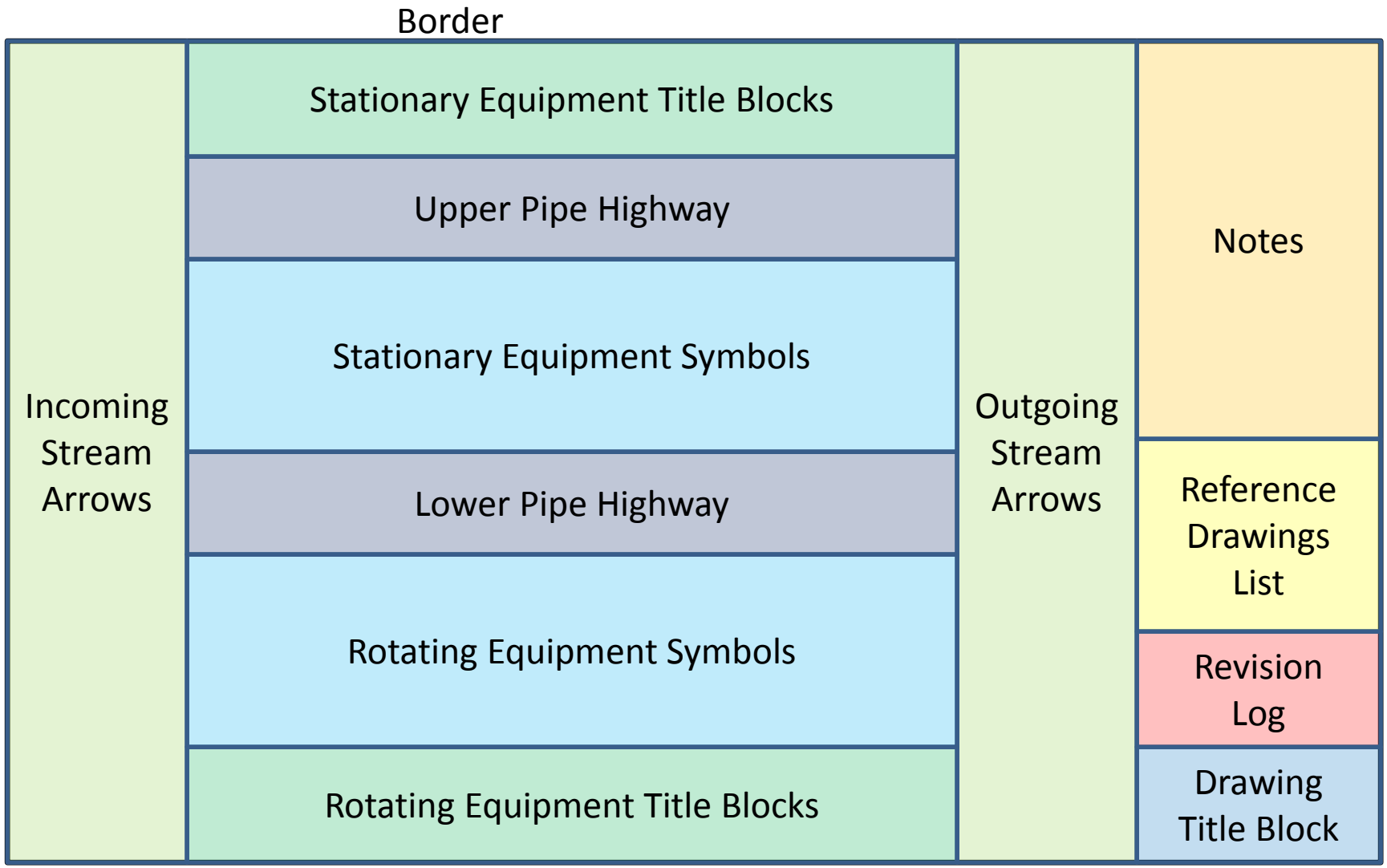
SHOWN ON P&ID



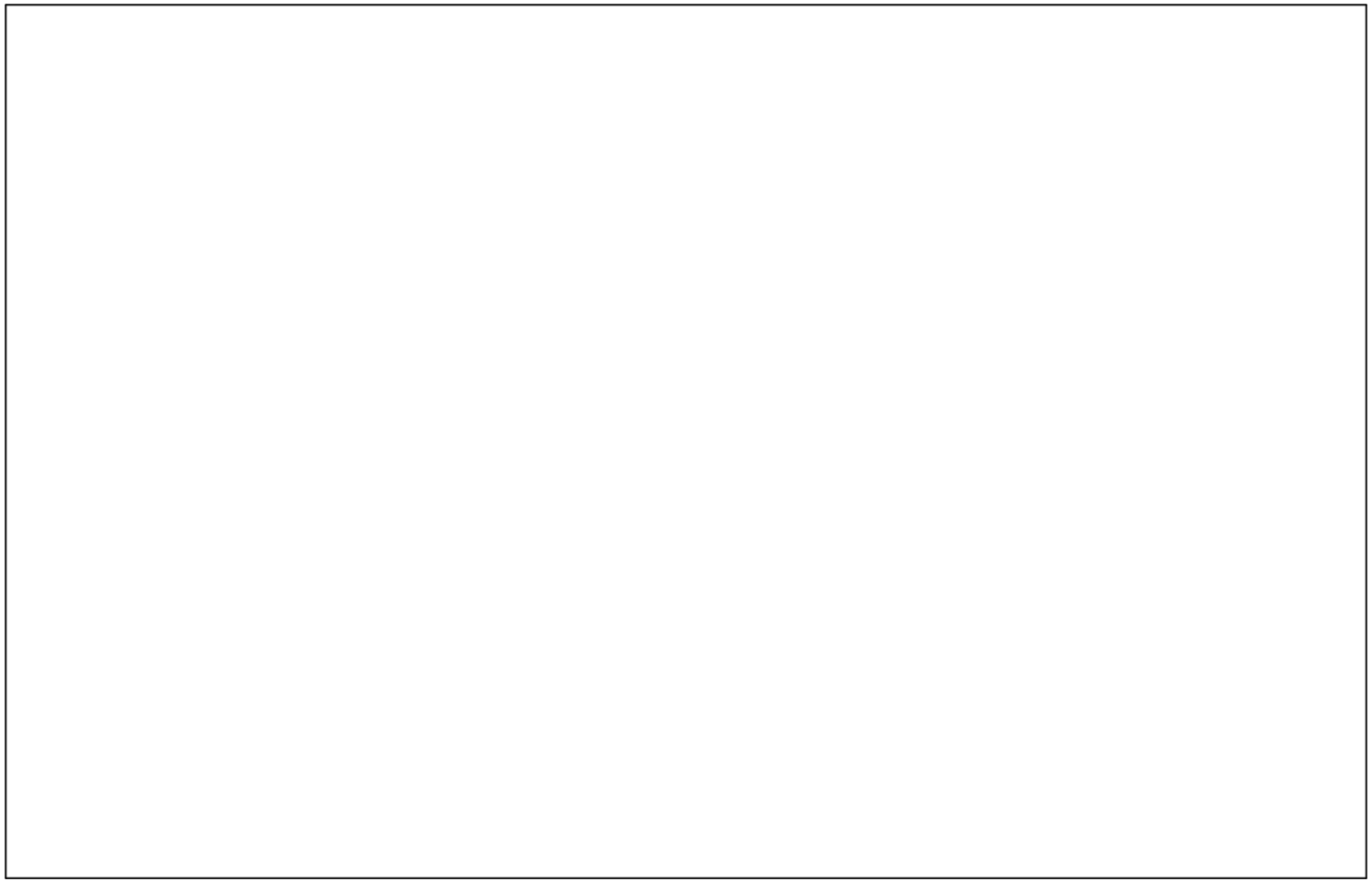
IMPLIED

Standardize On FORMAT

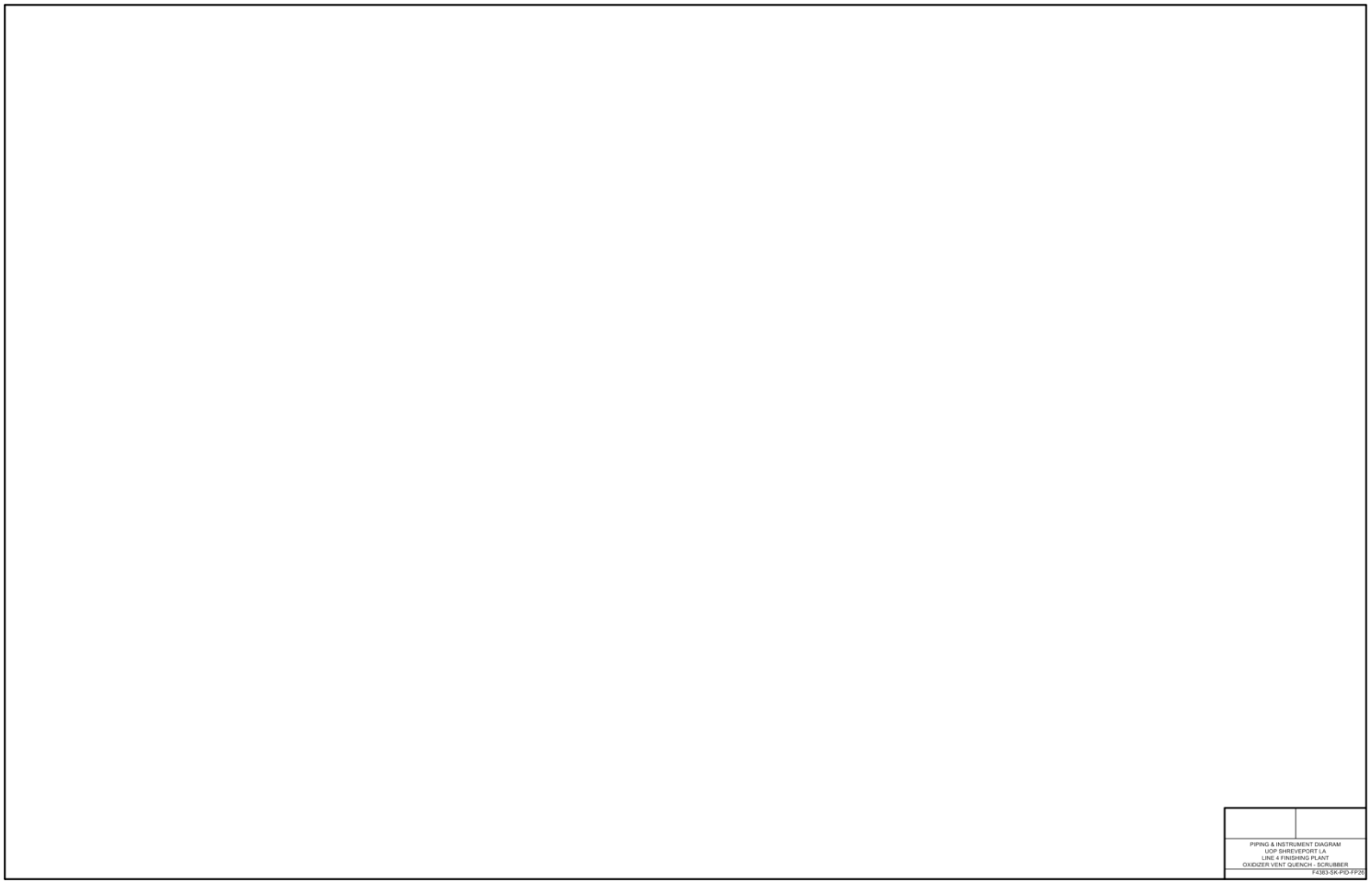
Standardize On FORMAT



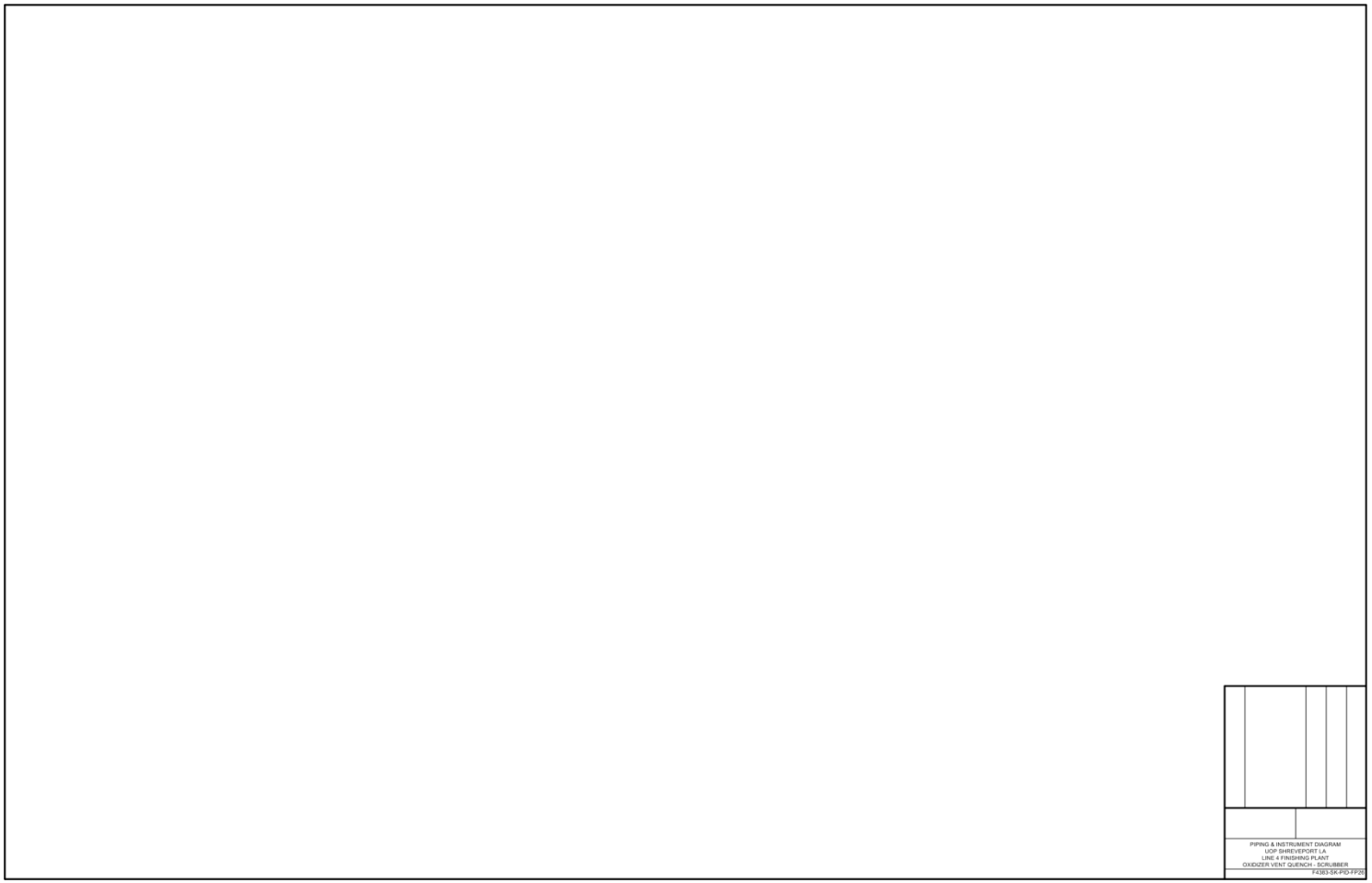
Border



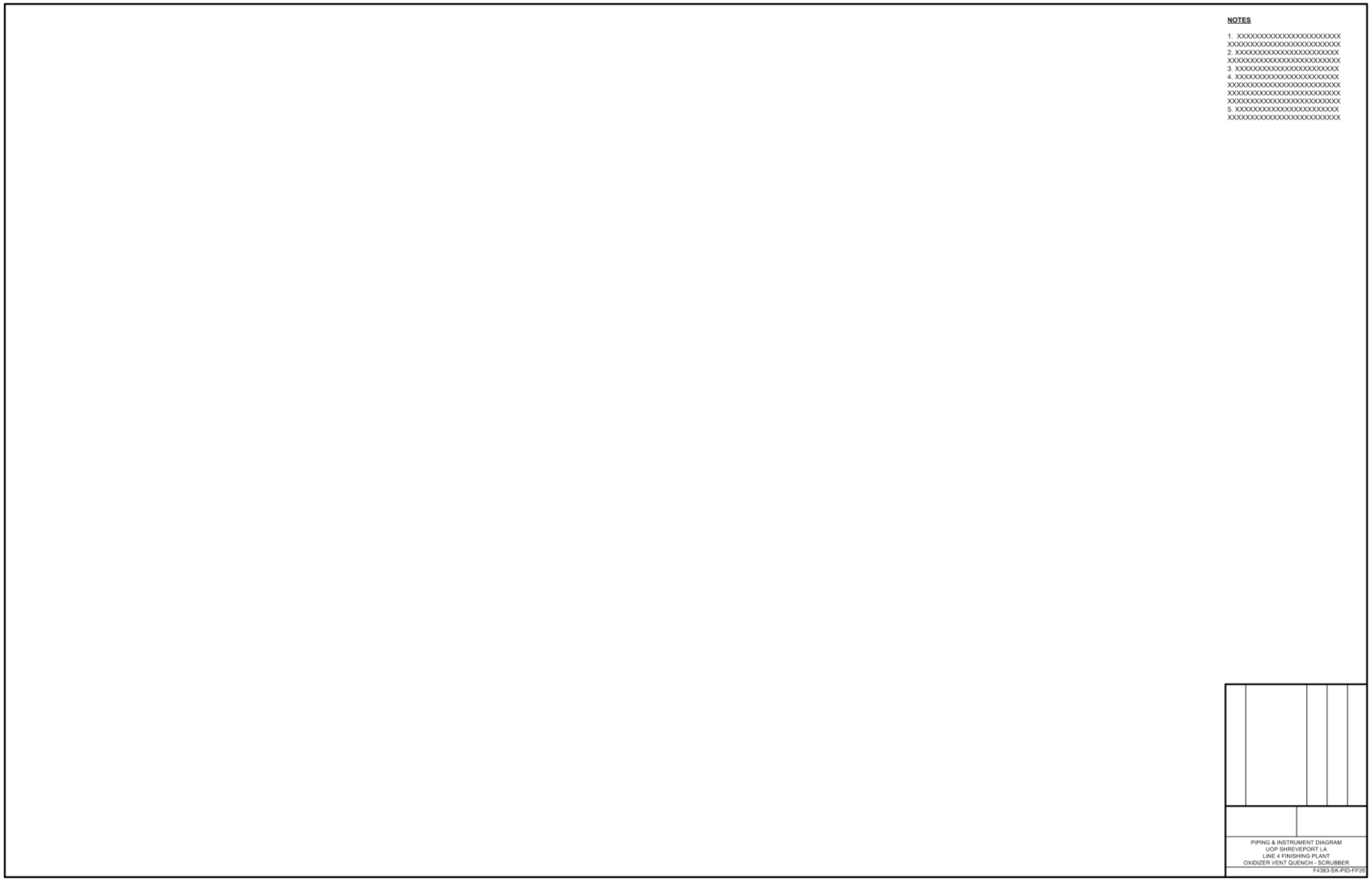
Drawing Title Block



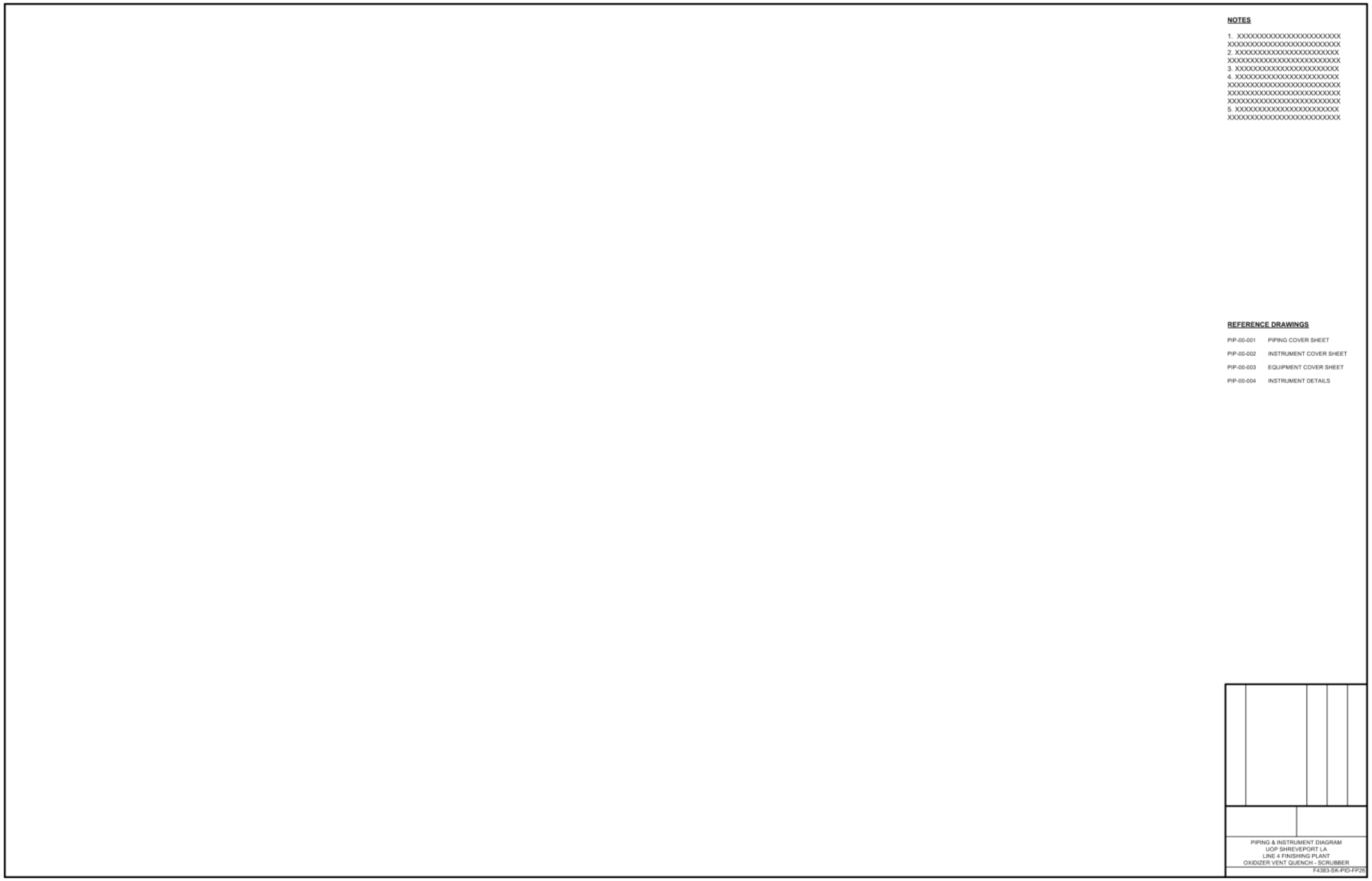
Revision Log



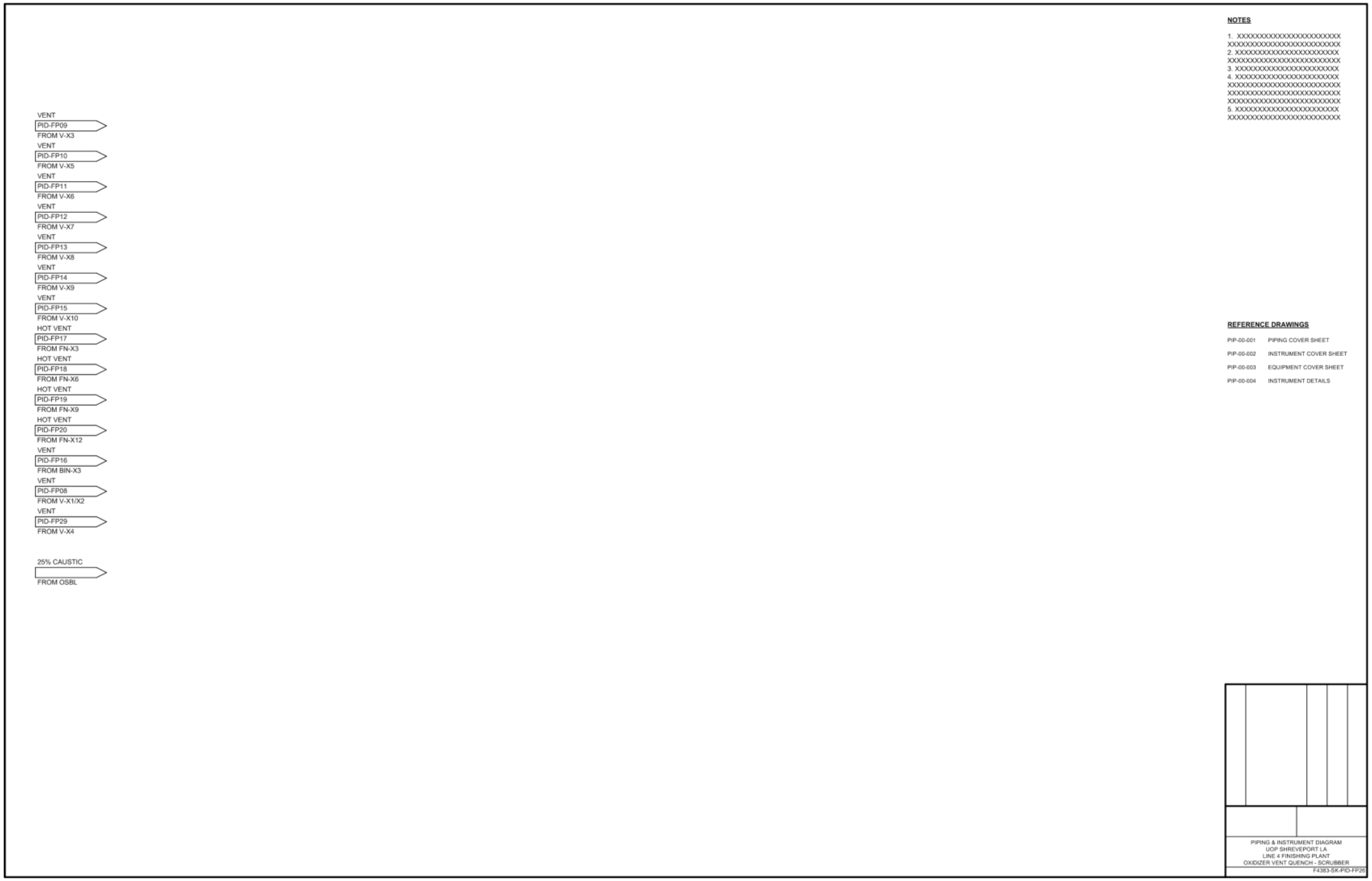
Notes


NOTES
1. XXXXXXXXXXXXXXXXXXXXXXXXX
XXXXXXXXXXXXXXXXXXXXXXXXXXX
2. XXXXXXXXXXXXXXXXXXXXXXXXX
XXXXXXXXXXXXXXXXXXXXXXXXXXX
3. XXXXXXXXXXXXXXXXXXXXXXXXX
4. XXXXXXXXXXXXXXXXXXXXXXXXX
XXXXXXXXXXXXXXXXXXXXXXXXXXX
XXXXXXXXXXXXXXXXXXXXXXXXXXX
XXXXXXXXXXXXXXXXXXXXXXXXXXX
5. XXXXXXXXXXXXXXXXXXXXXXXXX
XXXXXXXXXXXXXXXXXXXXXXXXXXX
PIPING & INSTRUMENT DIAGRAM
UOP SHREVEPORT LA
LINE 4 FINISHING PLANT
OXIDIZER VENT QUENCH - SCRUBBER
F4383-SK-PID-FP26

Reference Drawings List

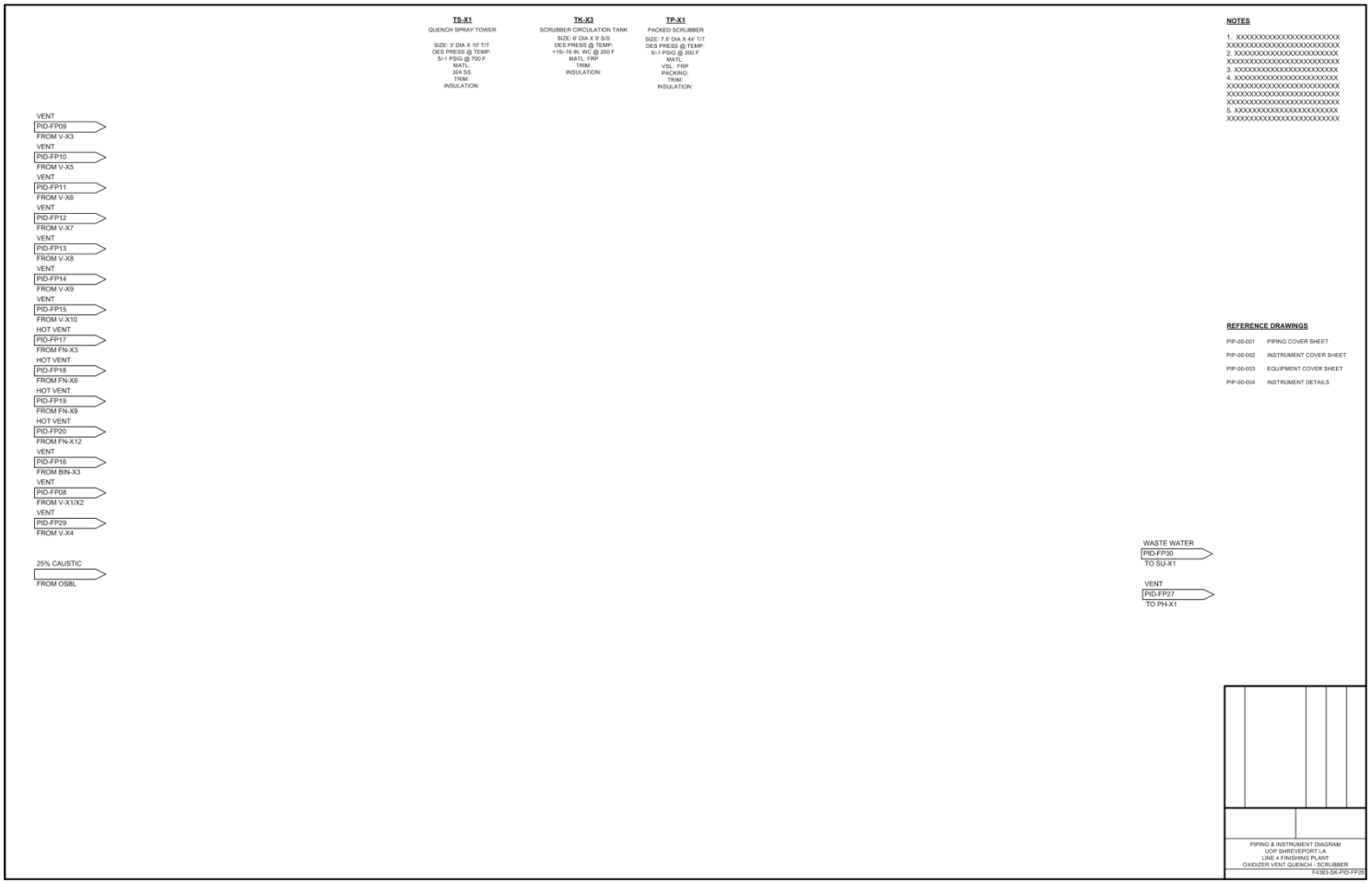


Incoming Stream Arrows

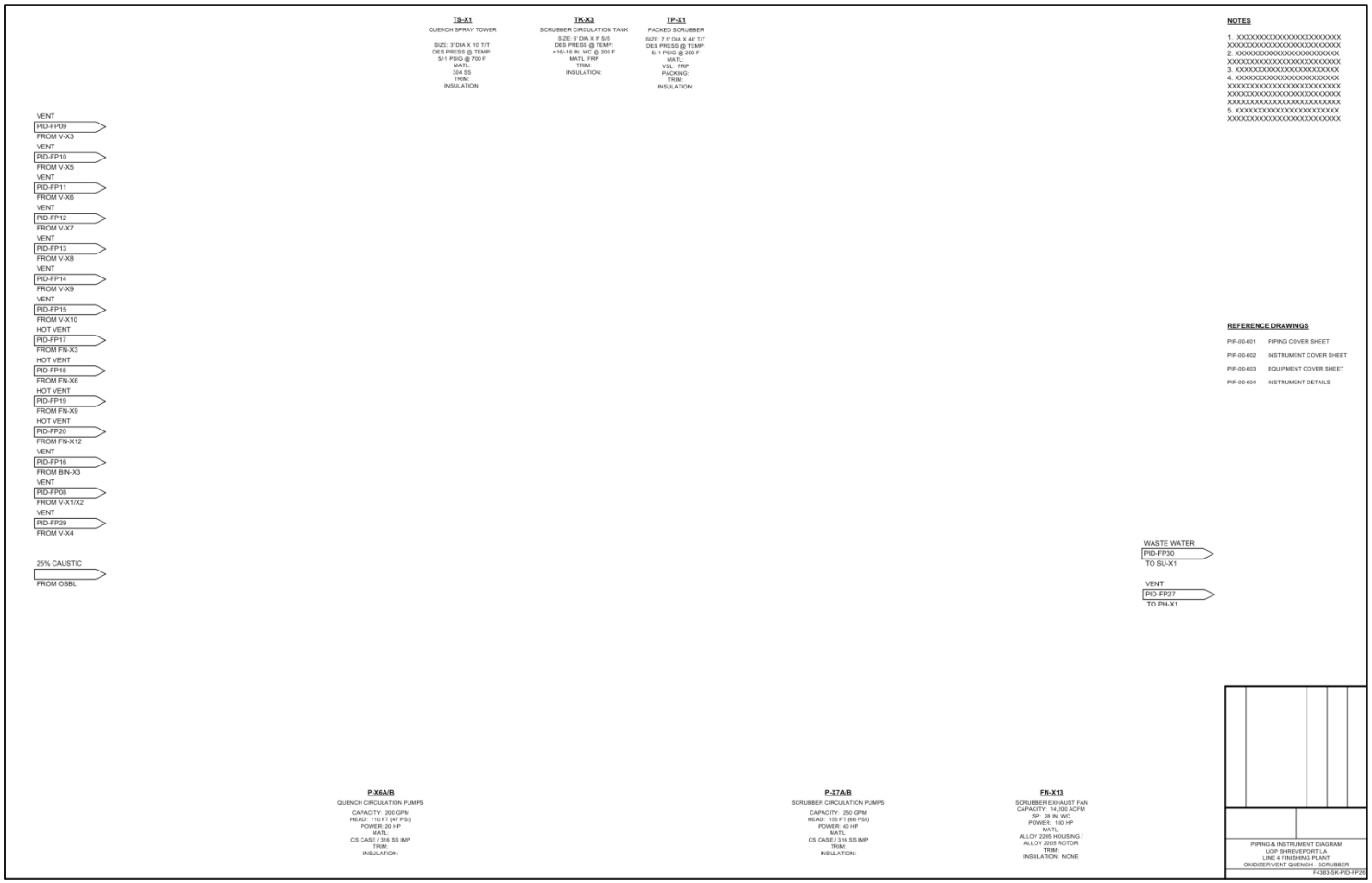


Outgoing Stream Arrows

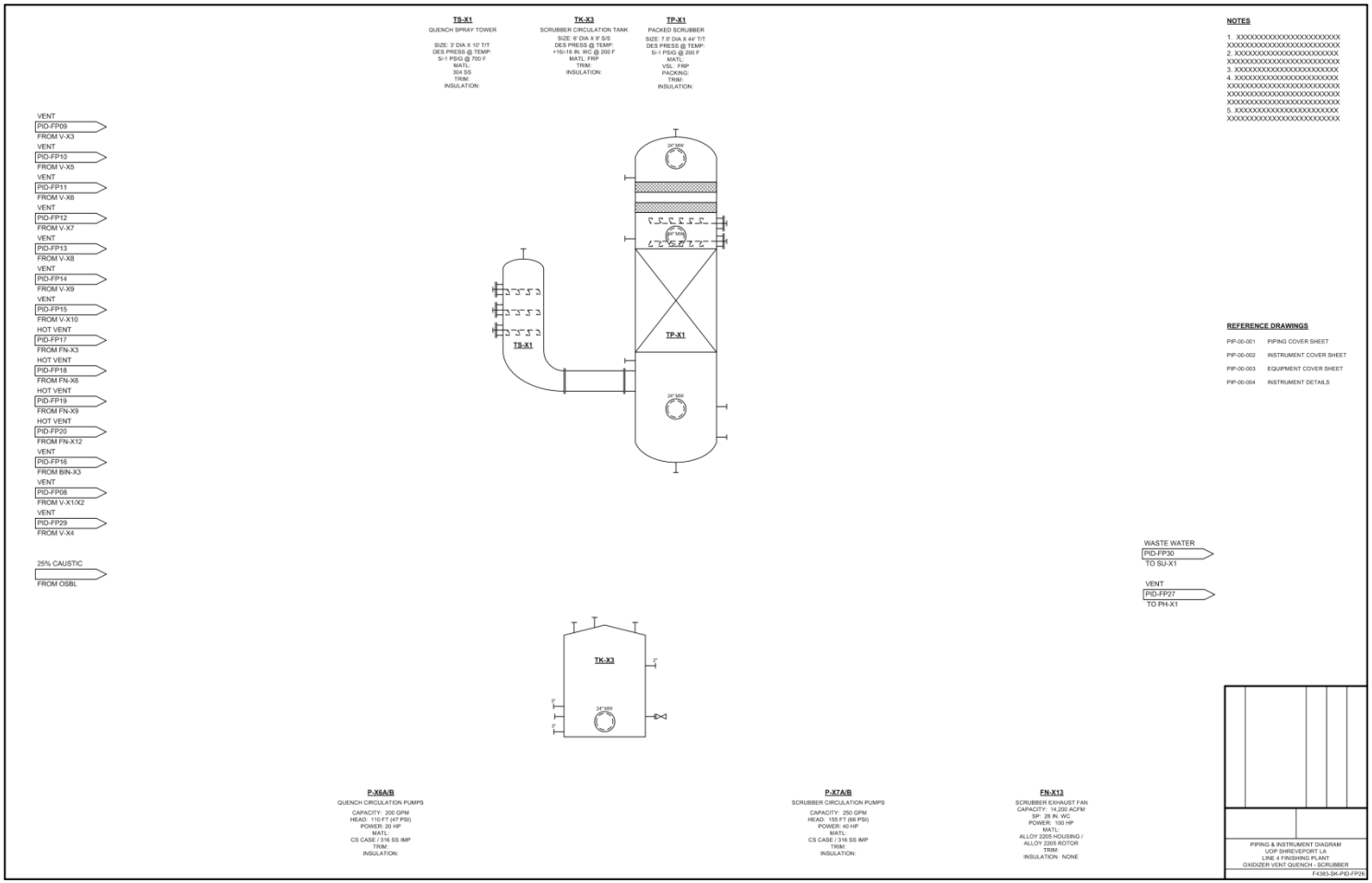
Stationary Equipment Title Blocks



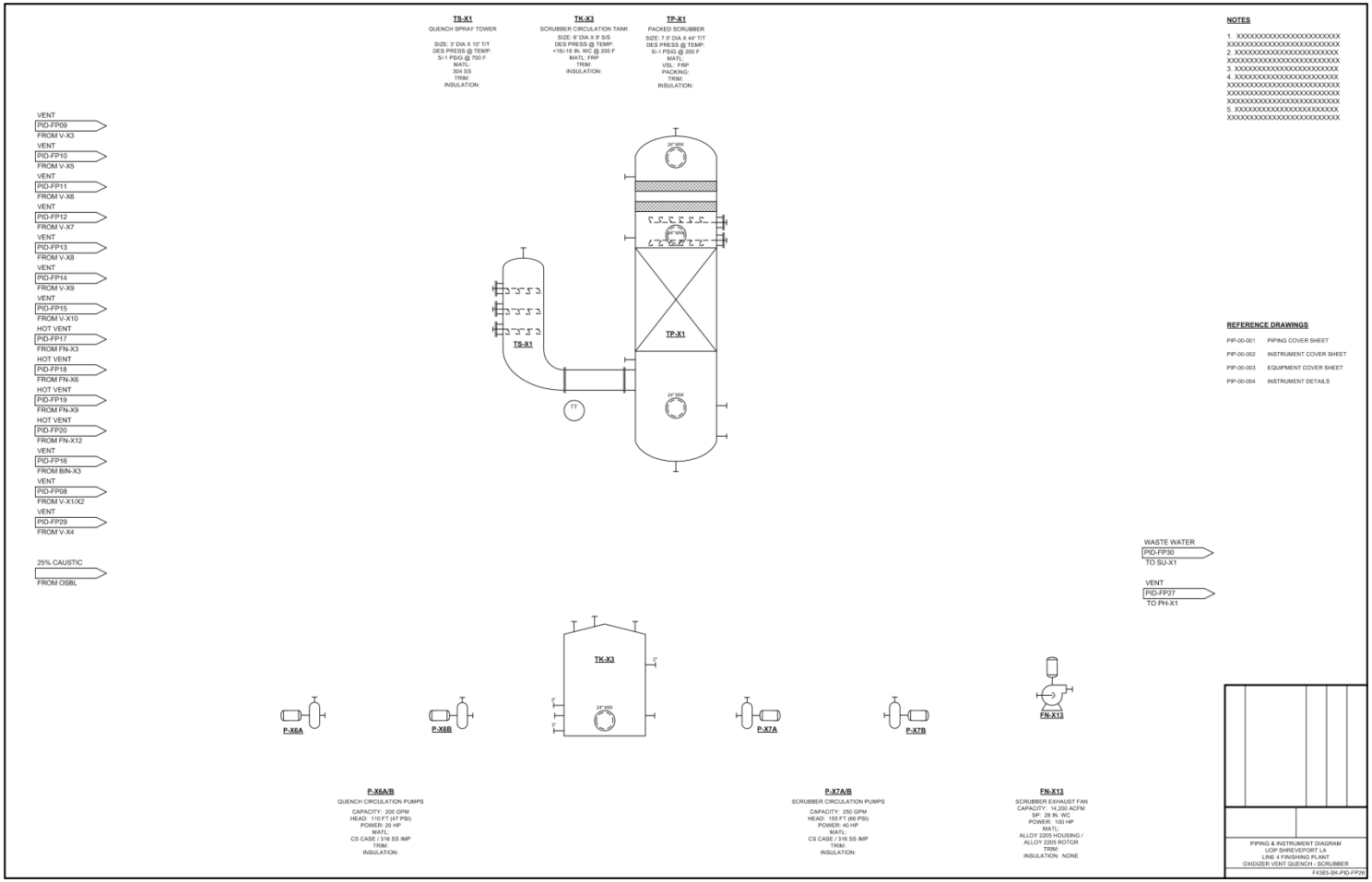
Rotating Equipment Title Blocks



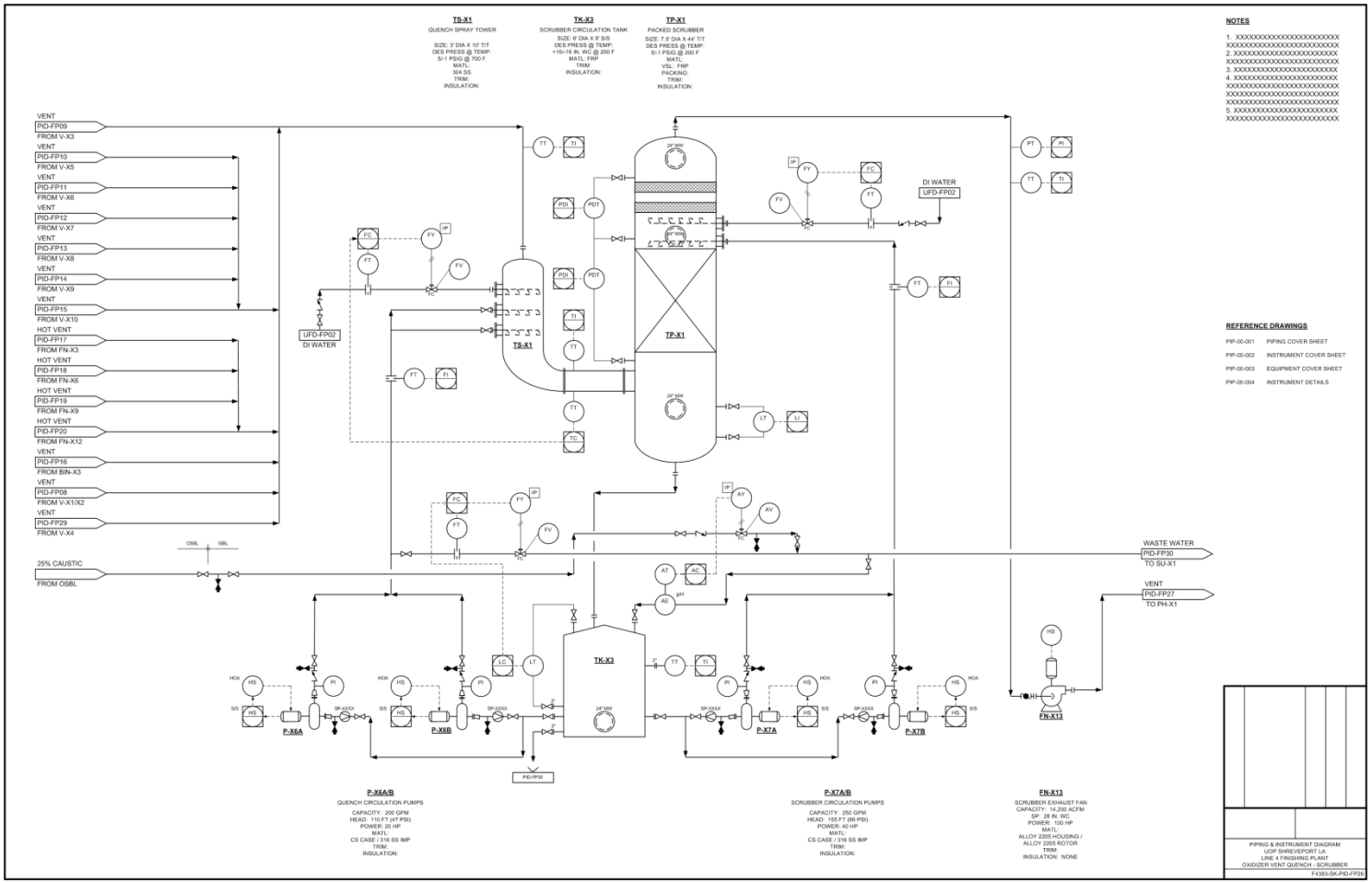
Stationary Equipment Symbols



Rotating Equipment Symbols



Final P&ID


TS-X1
QUENCH SPRAY TOWER
TK-X3
SCRUBBER CIRCULATION TANK
TP-X1
PACKED SCRUBBER
NOTES
REFERENCE DRAWINGS
VENT
PID-FP09
FROM V-X3
PID-FP10
FROM V-X5
PID-FP11
FROM V-X6
PID-FP12
FROM V-X7
PID-FP13
FROM V-X8
PID-FP14
FROM V-X9
PID-FP15
FROM V-X10
HOT VENT
PID-FP17
FROM FN-X3
PID-FP18
FROM FN-X6
PID-FP19
FROM FN-X9
PID-FP20
FROM FN-X12
PID-FP16
FROM BIN-X3
PID-FP08
FROM V-X1/X2
PID-FP29
FROM V-X4
25% CAUSTIC
FROM OSBL
DI WATER
UFD-FP02
WASTE WATER
PID-FP30
TO SU-X1
VENT
PID-FP27
TO PH-X1
P-X6A
P-X6B
P-X7A
P-X7B
FN-X13
P-X6A/B
QUENCH CIRCULATION PUMPS
P-X7A/B
SCRUBBER CIRCULATION PUMPS
PIPING & INSTRUMENT DIAGRAM
UOP SHREVEPORT LA
LINE 4 FINISHING PLANT
OXIDIZER VENT QUENCH - SCRUBBER

P&ID Drafting Standards

- P&ID Drafting Procedure (Client)
- Drawing Size
- Borders
- Drawing Title Block
- Equipment Title Blocks
- Layers
- Line Weights
- Fonts

P&ID Drawing Size

- Standard P&ID Drawing Size Is ANSI D Which Is 22” High By 34” Wide

- 11” X 17” Size (ANSI B) Is Typically Used For Reference Is A Reduction Of The Standard Size

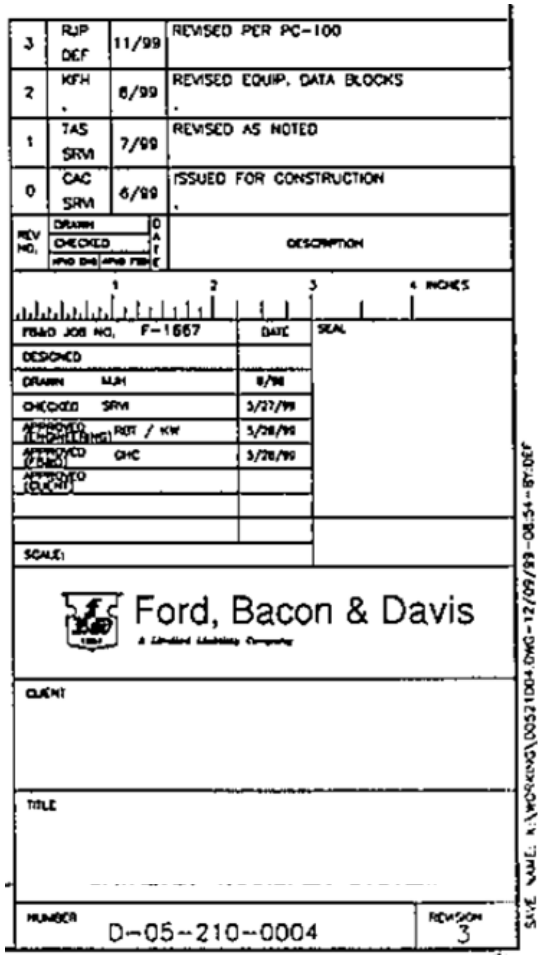
P&ID Borders

- Identifies Boundary Of Drawing Content
- Spacing Between Edge Of Drawing And Border To Allow For Copy Misalignment
- Thickness Of Border Line May Vary
- Drawing File Name Usually Outside Of Border

P&ID Drawing Title Block

- Client Name And Logo
- Location
- Drawing Subject Information
- Drawing Number
- Revision Number
- General Drafting Information
- Revision Description

P&ID Drawing Title Block



P&ID Drawing Subject (Typical)

- First Line: Plant Or Unit Or Project
- Second Line: Type Of Drawing
  - Piping & Instrument Diagram
  - Process Flow Diagram
  - Process Block Diagram
- Third Line: Process Section Of Plant Or Unit
- Fourth Line: Key Equipment Description

P&ID Drawing Number

- Client Usually Has Specific System For Numbering Drawings
- Typical Drawing Number Format
  - Drawing Size Designator
  - Plant/Unit/Process Section Designator
  - Type Of Drawing Designator
  - Sequential Drawing Number

Example P&ID Drawing Number

- Example: D-1015-G-00233
- D = Drawing Size (22” X 34”)
- 1015 = Unit Number
- G = Flow Diagram
- 00233 = Sequential Number

P&ID Revision Description

- Drawings For A Project Are Generally Issued At Different Stages Of Development
- Each Stage More Complete Than The Preceding Stage
- Typical Stages:
  - Issue For Client Comment (IFCC) Or Preliminary Issue
  - Issue For Approval (IFA)
  - Issue For Design (IFD)
  - Issue For Construction (IFC)
  - Issue For Record (IFR)

Rev No – New P&ID

- New Drawing Will Carry a Revision Letter A, B, C, Etc. During Preliminary, Approval, and Design Issues
- Drawing is Typically Issued For Construction As Revision 0 (Zero)
- Any Further Revisions Carry Revision Numbers (1, 2, 3, Etc.)
- Revision Description For New Drawing Will Use Issue Description (IFCC, IFA, IFD, IFC, IFR)

Rev No – Existing P&ID

- Existing Drawing Revised For A Project Will Carry The Next Revision Number Followed By A Letter A, B, C, Etc. During Preliminary, Approval, And Design Issues

- When The Drawing Is Issued For Construction, The Letter Designation Is Dropped From The Revision Number

- The Revision Description For A Revised Drawing Will Typically Use The Project Title Along With Development Stage (IFCC, IFA, IFD, IFC, IFR)

Standardize On FORMAT

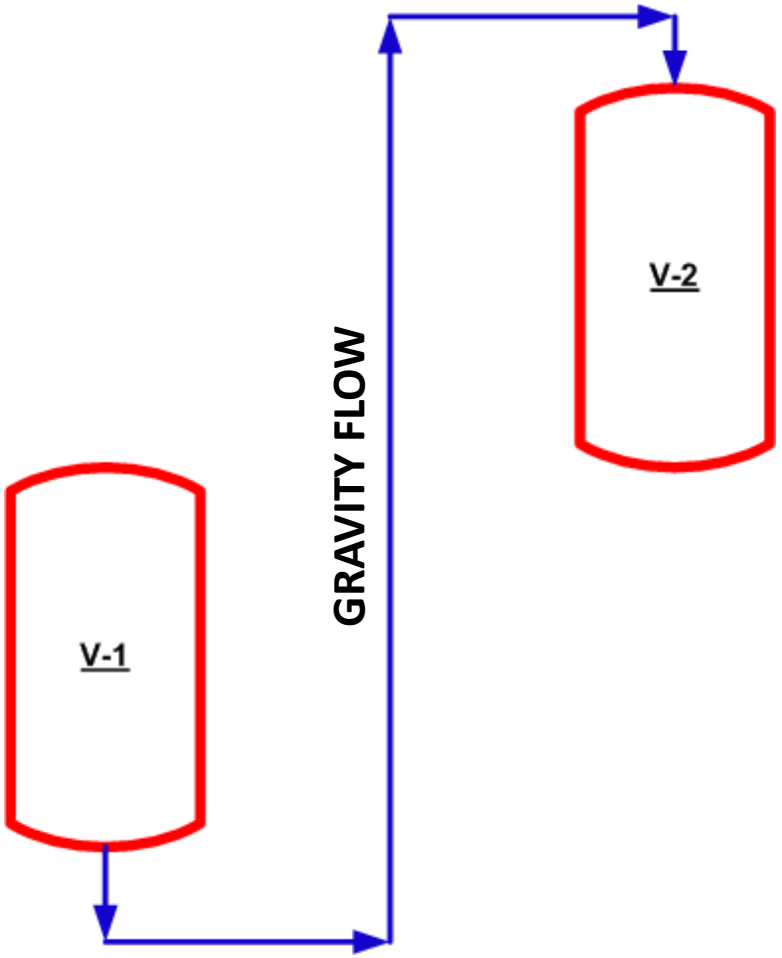
- Select Meaningful Drawing Titles
- Update Drawing Titles As P&ID Content Changes
- Keep Revision Log Up To Date

LAYOUT
For Clarity

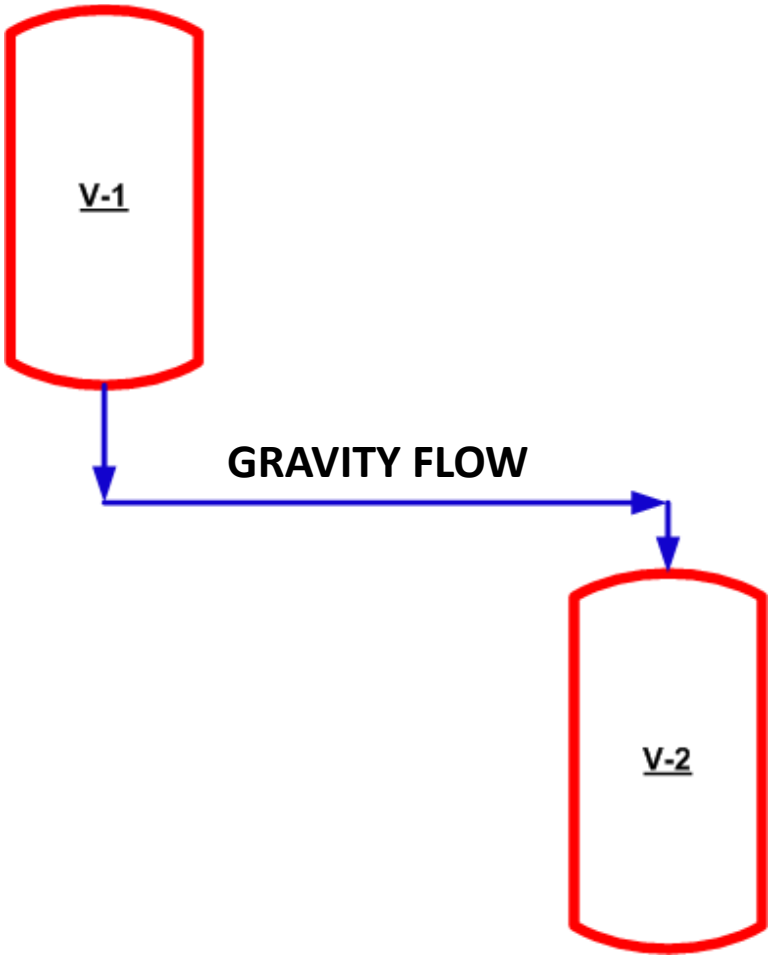
LAYOUT For Clarity

- P&IDs Are Conceptual Drawings
- However, Presentation Should Reflect Reality As Much As Possible
- Pipers' Trap:
  - Why Didn't You Design It Like The P&ID?
  - *The P&ID Is A Conceptual Drawing!*
  - Why Did You Design It This Way?
  - *I Designed It Just Like The P&ID Showed It!*

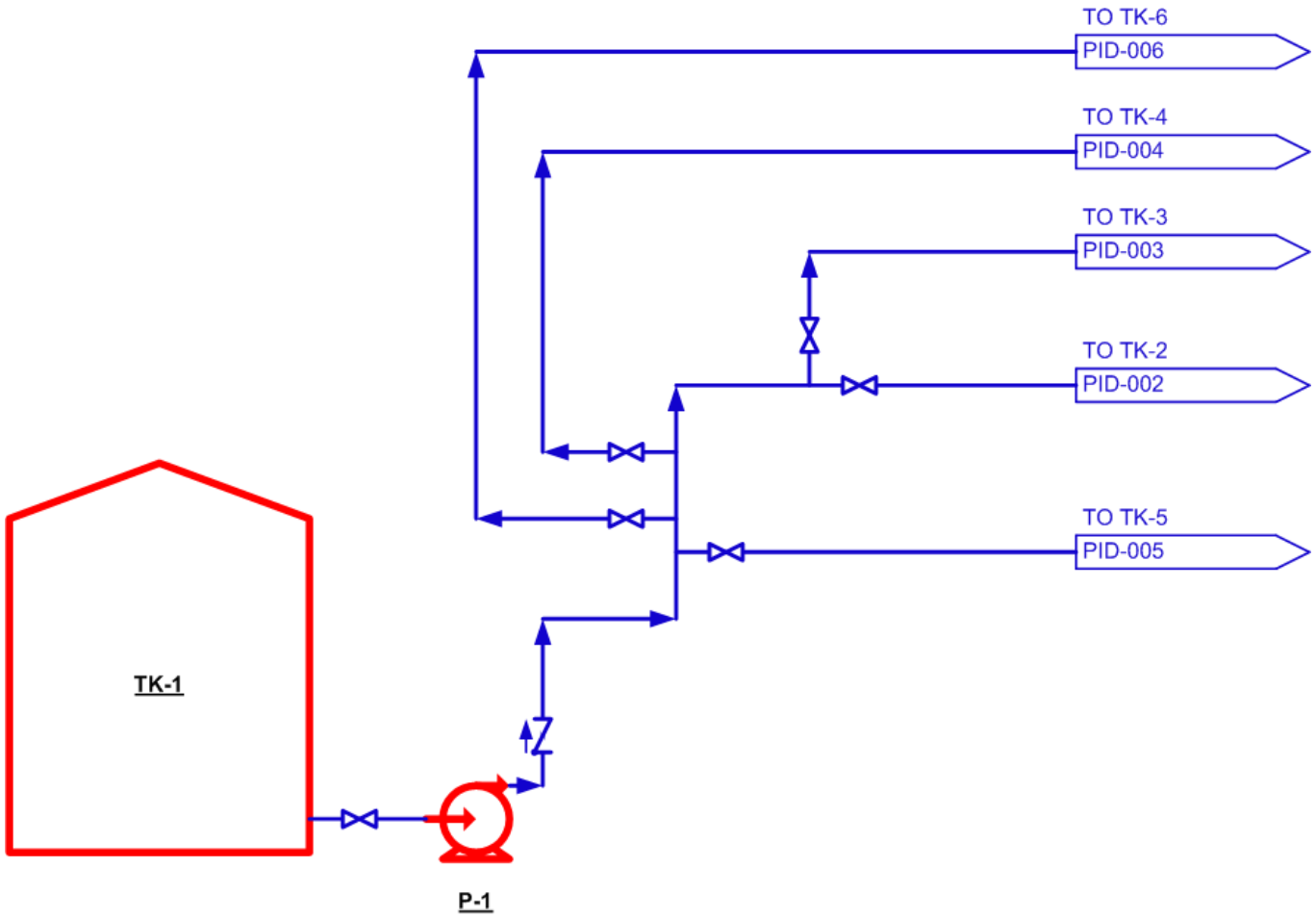
LAYOUT For Clarity



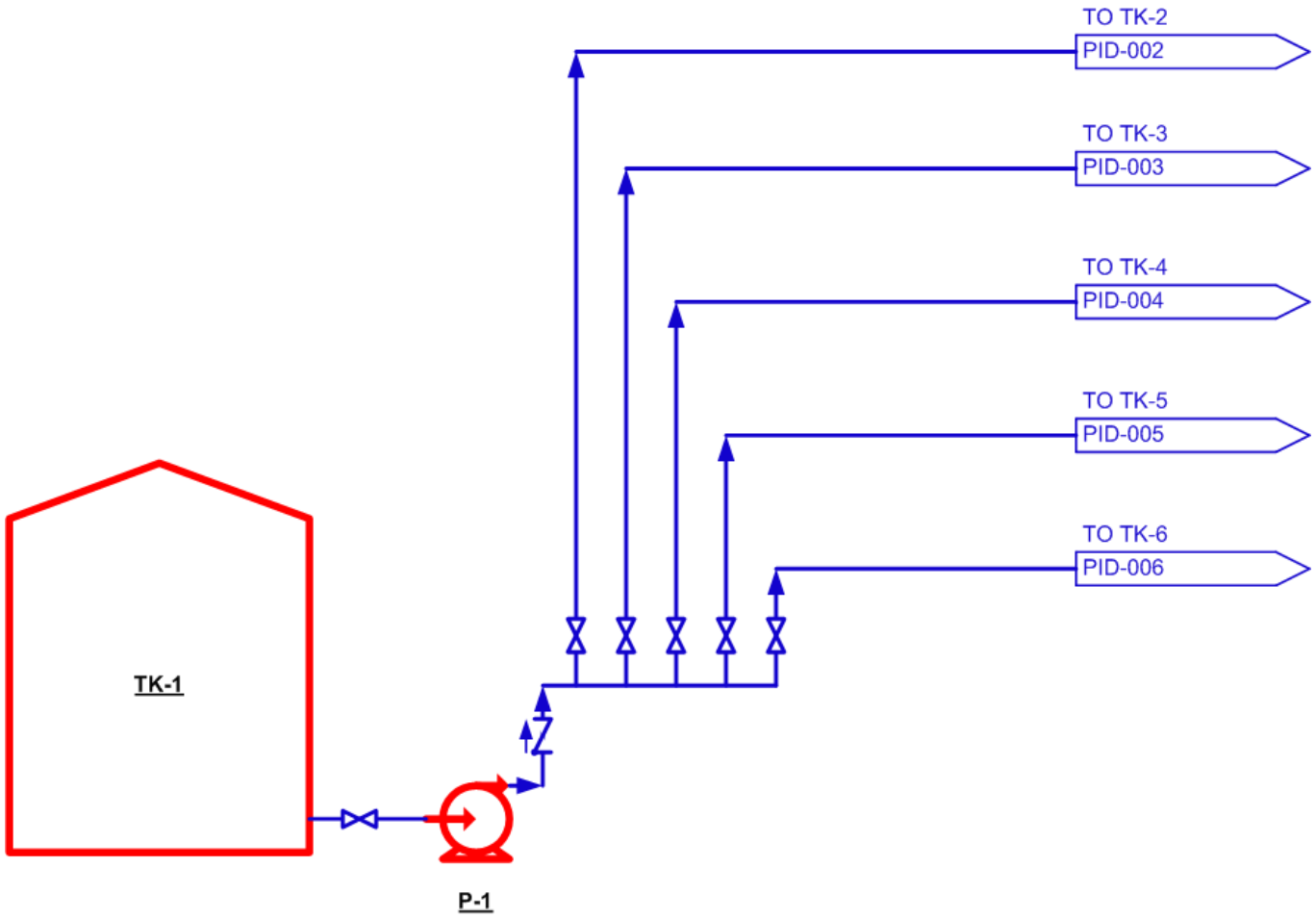
LAYOUT For Clarity



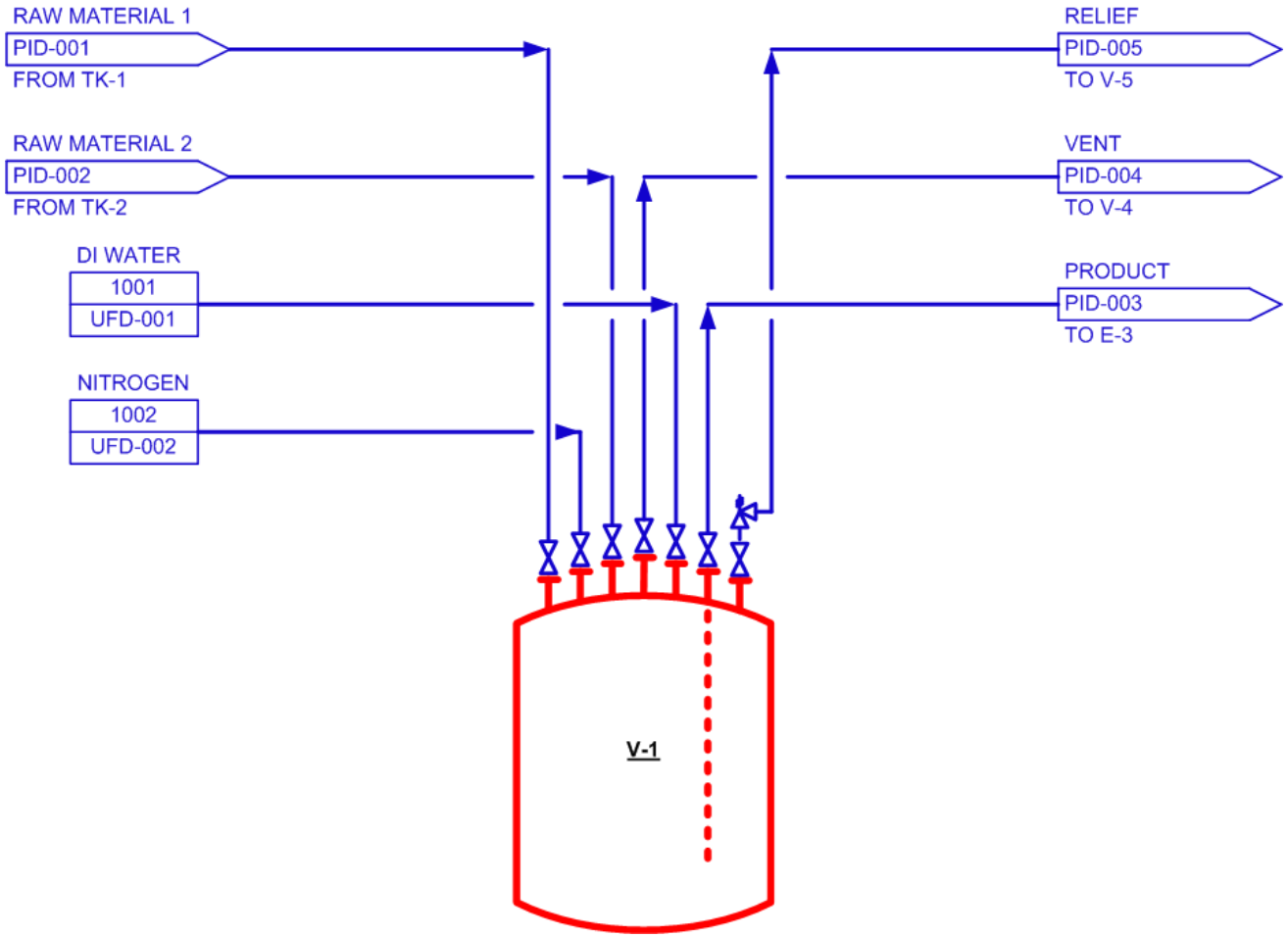
LAYOUT For Clarity



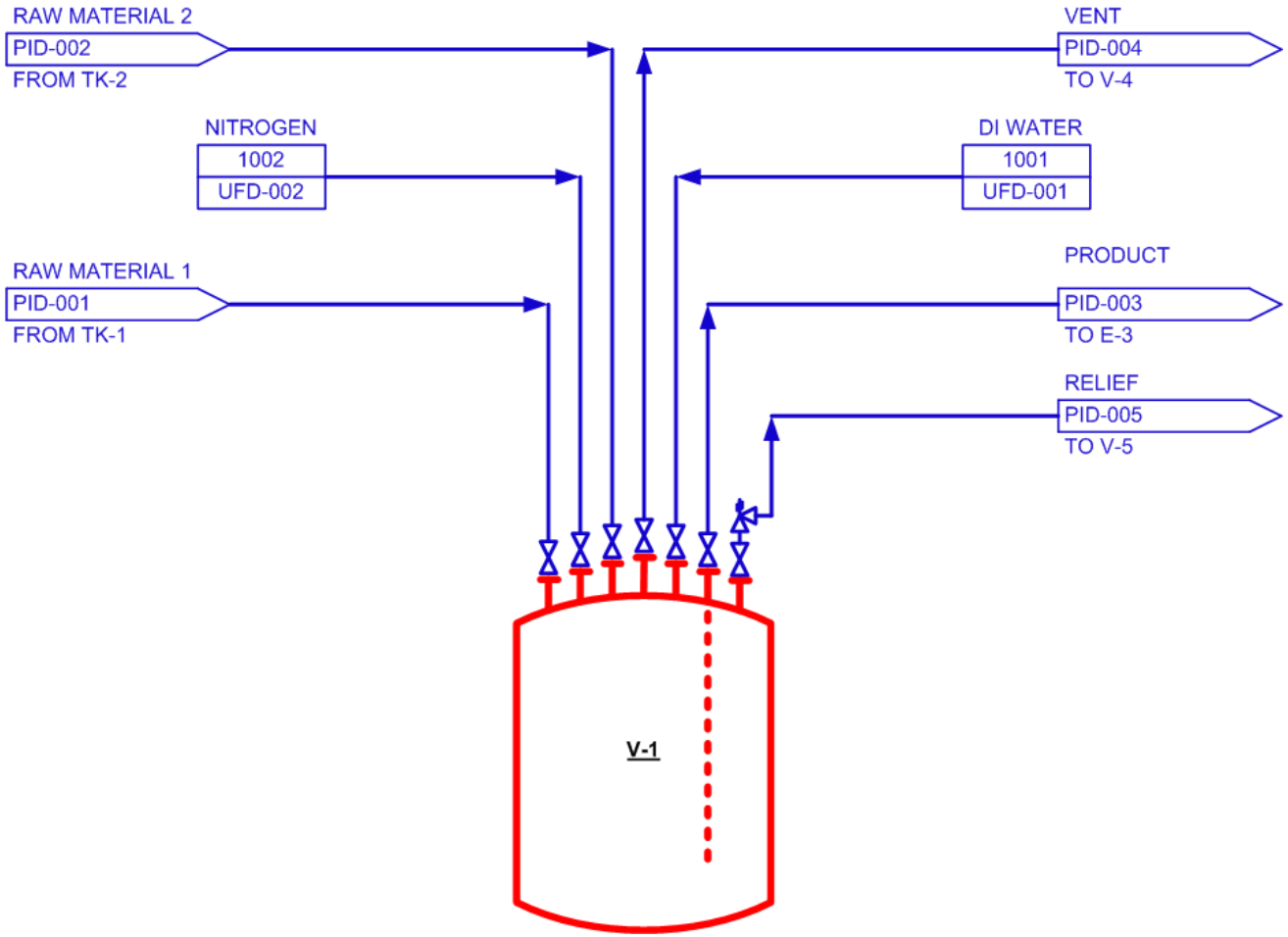
LAYOUT For Clarity



LAYOUT For Clarity



LAYOUT For Clarity



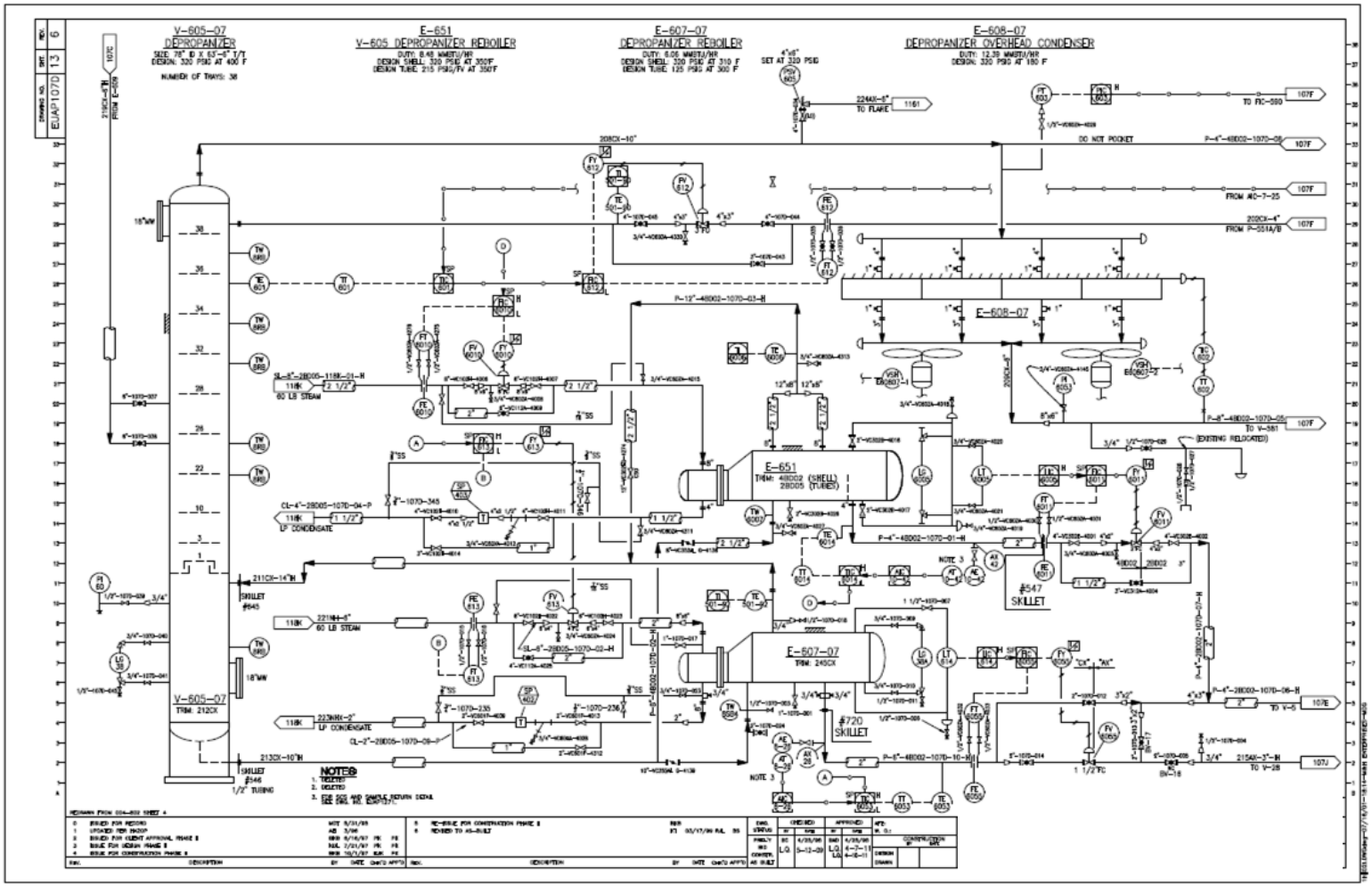
LAYOUT For Clarity

- Develop A Preliminary P&ID List Based On PFD Review
- Assign Which Equipment Goes On Each Drawing
- Minimize Drawing Density
- Leave Room For Other Disciplines To Add Their Symbology And Tags

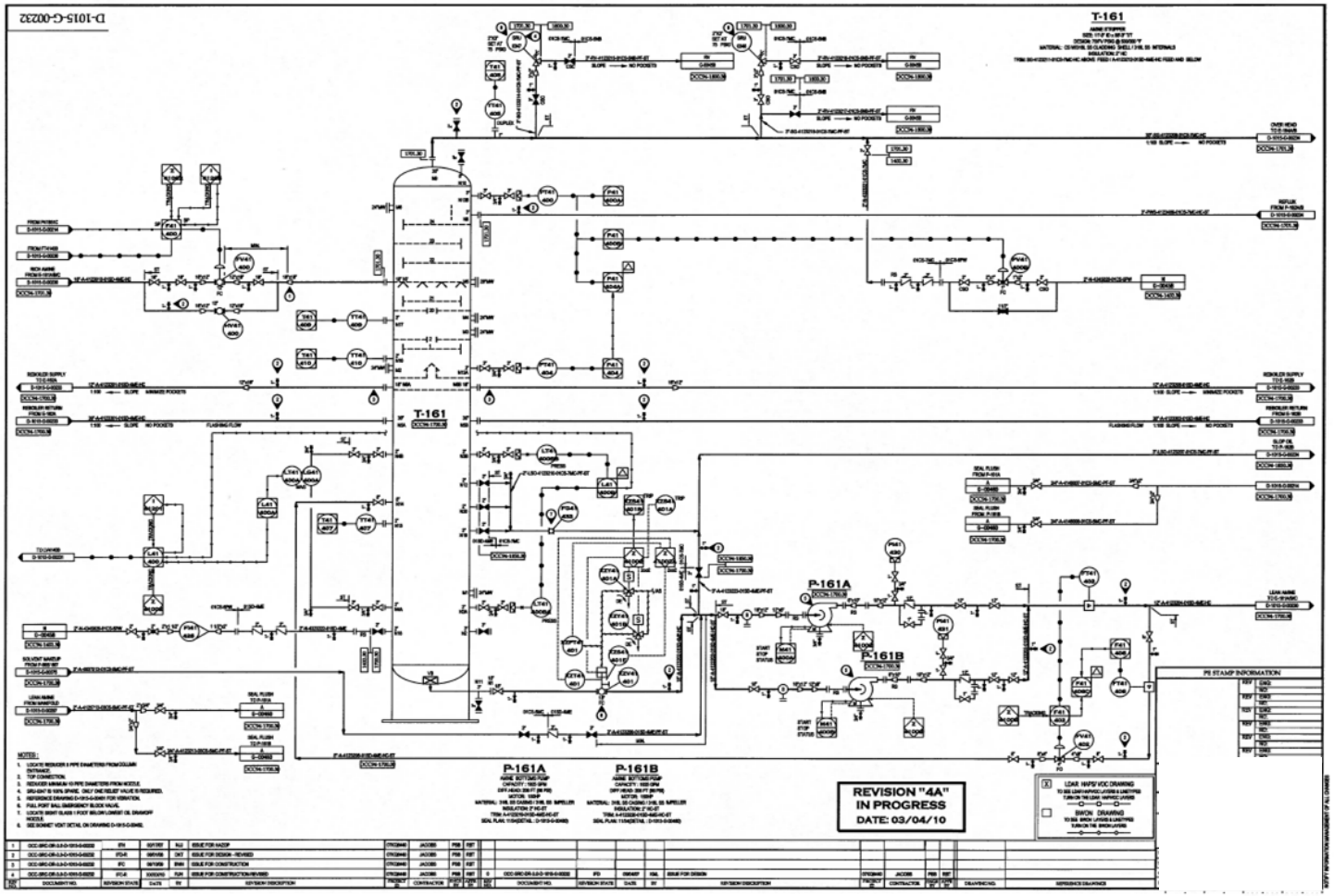
Layout Recommendations

Equipment	Number Of Items On One P&ID
Columns	1
Compressors	1 (Complex)
Fired Heaters	1
Packaging Equipment	Complete System If Possible
Pressure Vessels	Feed – 1 to 2 Reflux - 1 (Include With Condenser) Storage – 1 to 2
Pumps	Include With Related Equipment (Suction)
Tanks	1 to 2

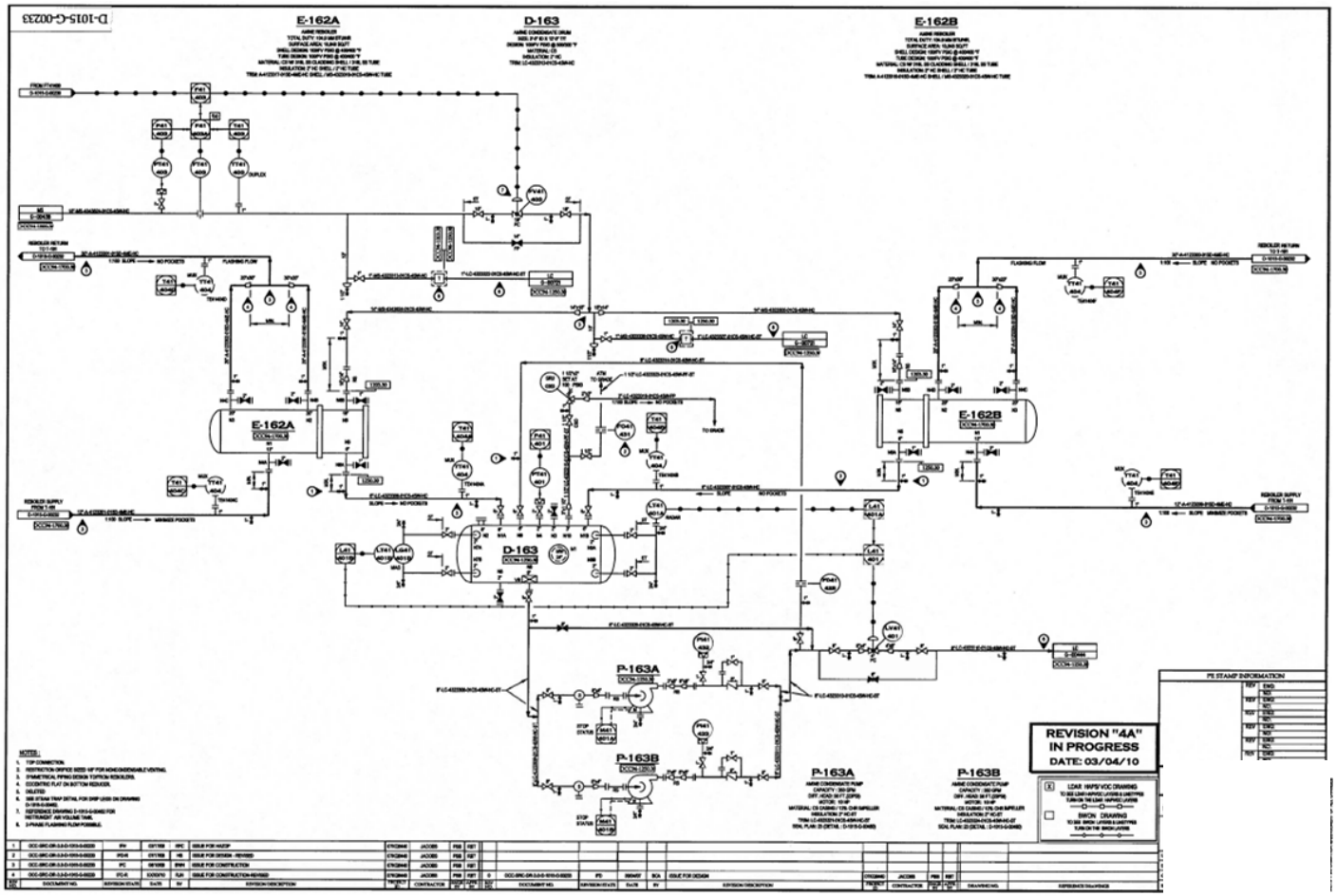
Column Systems (Combined)



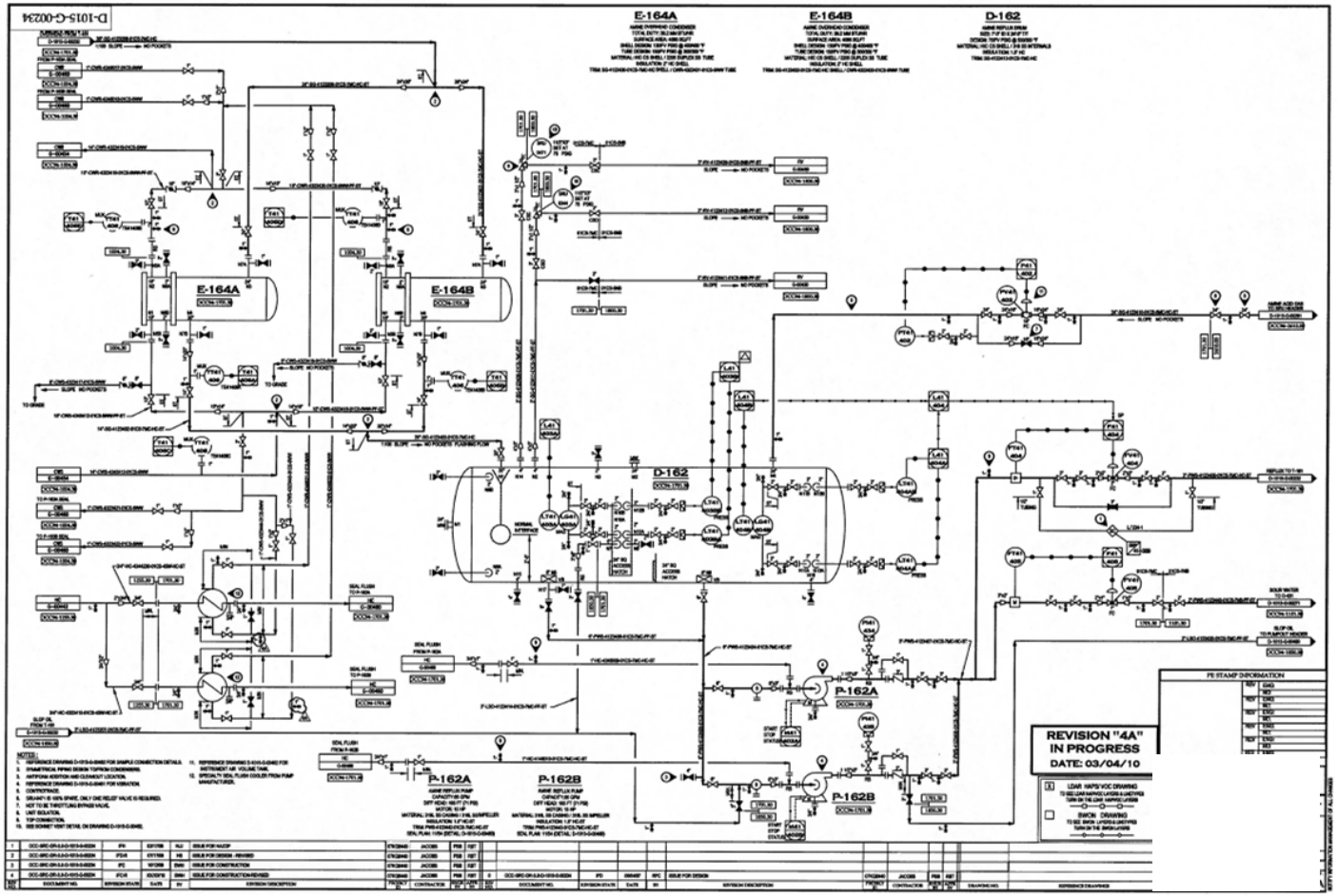
Column Systems (Column)



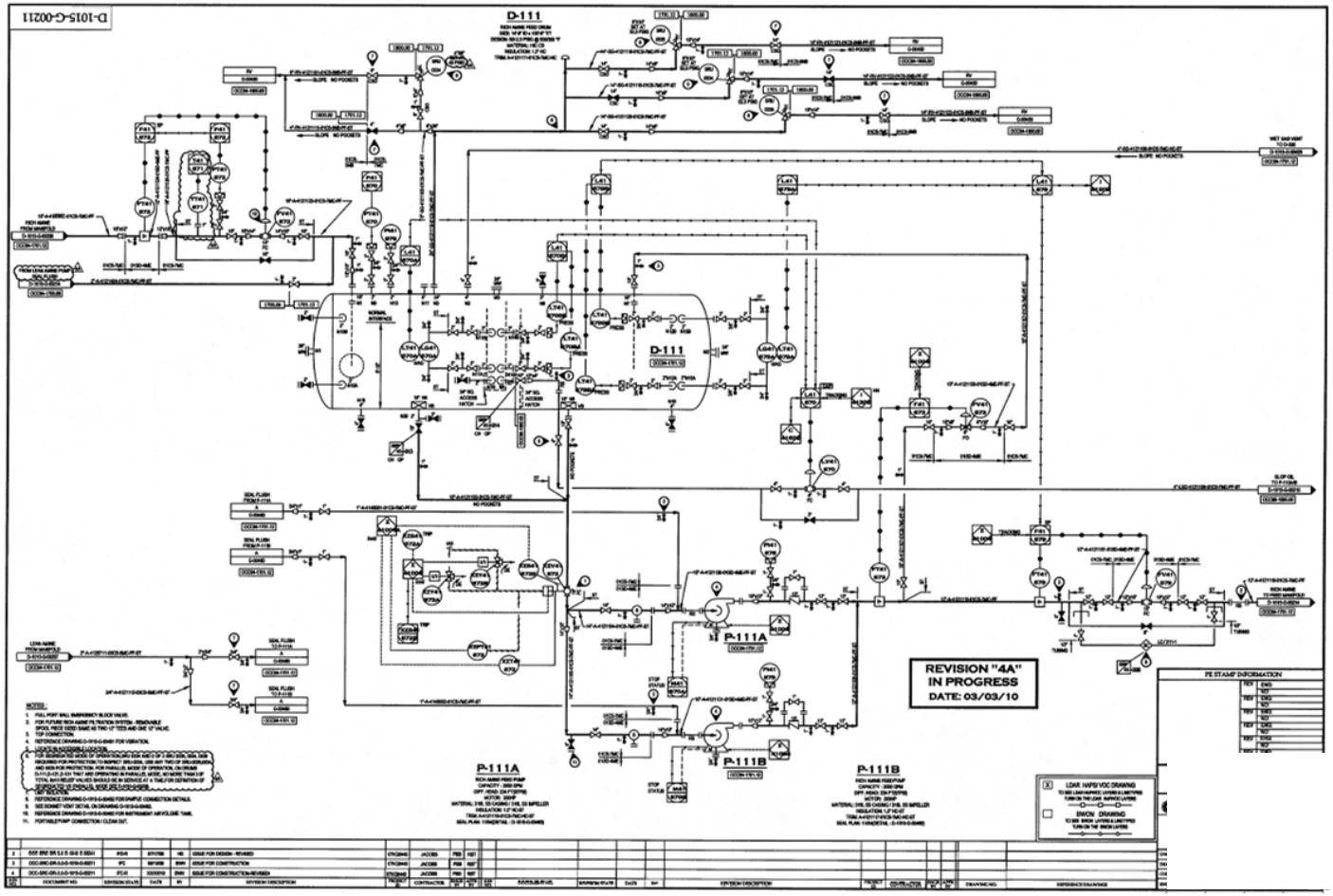
Column Systems (Reboilers)



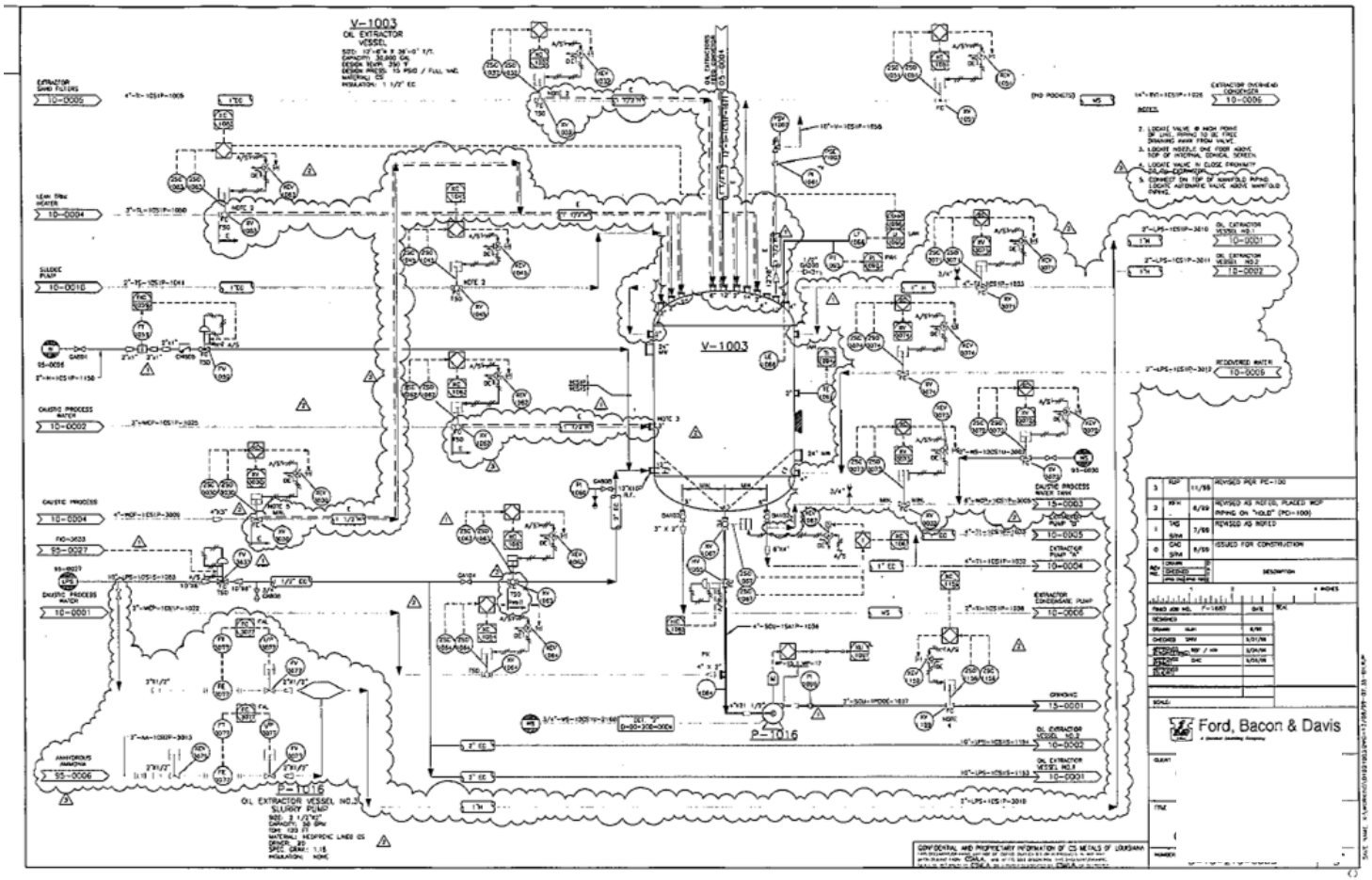
Column Systems (Overhead)



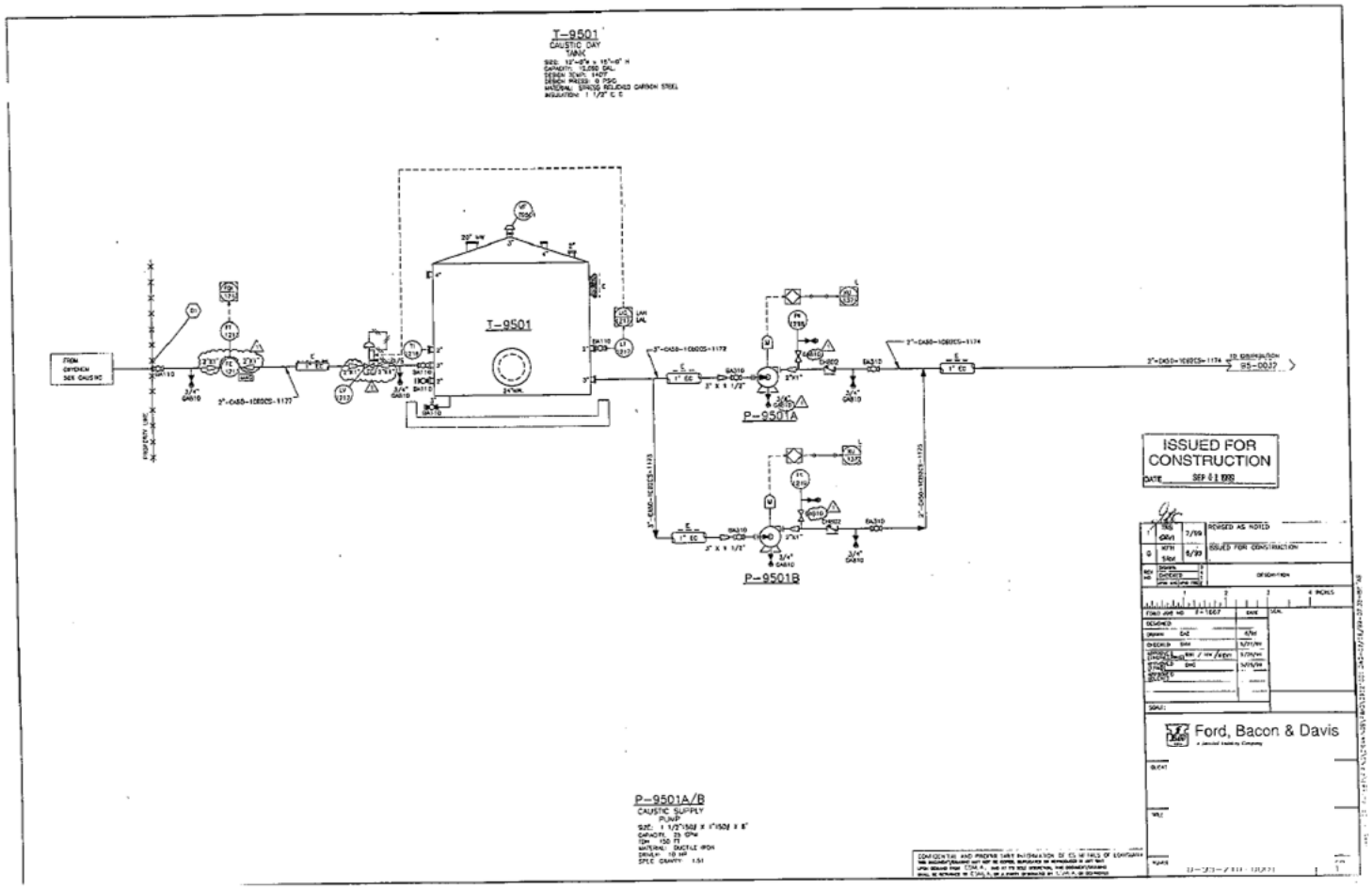
Drum (Horizontal)



Drum (Vertical)



Storage Tank

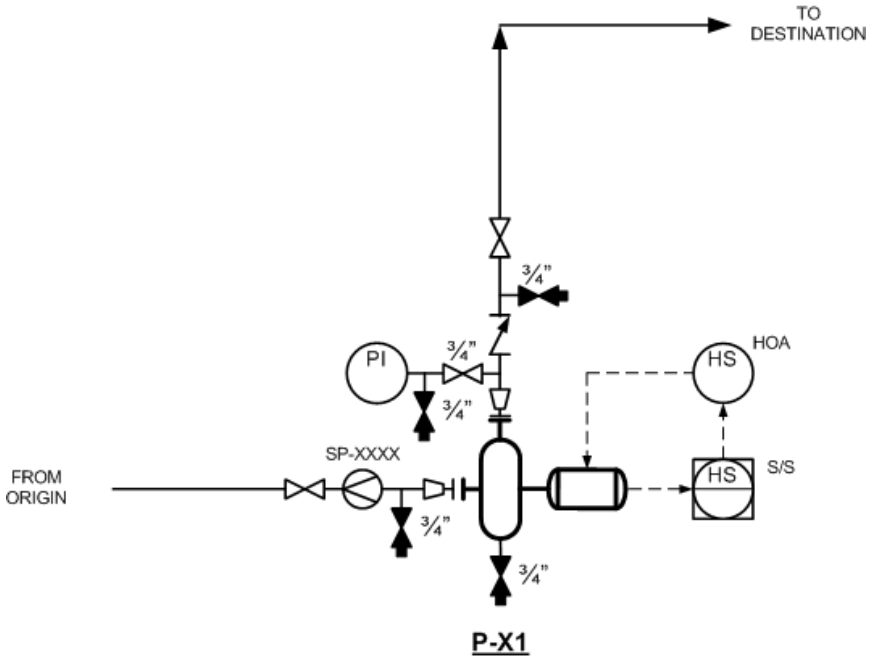


ANALYZE
Content For Accuracy

ANALYZE Content For Accuracy

- Standardize On Unit Operation Configurations
- Use P&ID Checklists To Validate Content
- Build Set Of Archive P&IDs For Reference

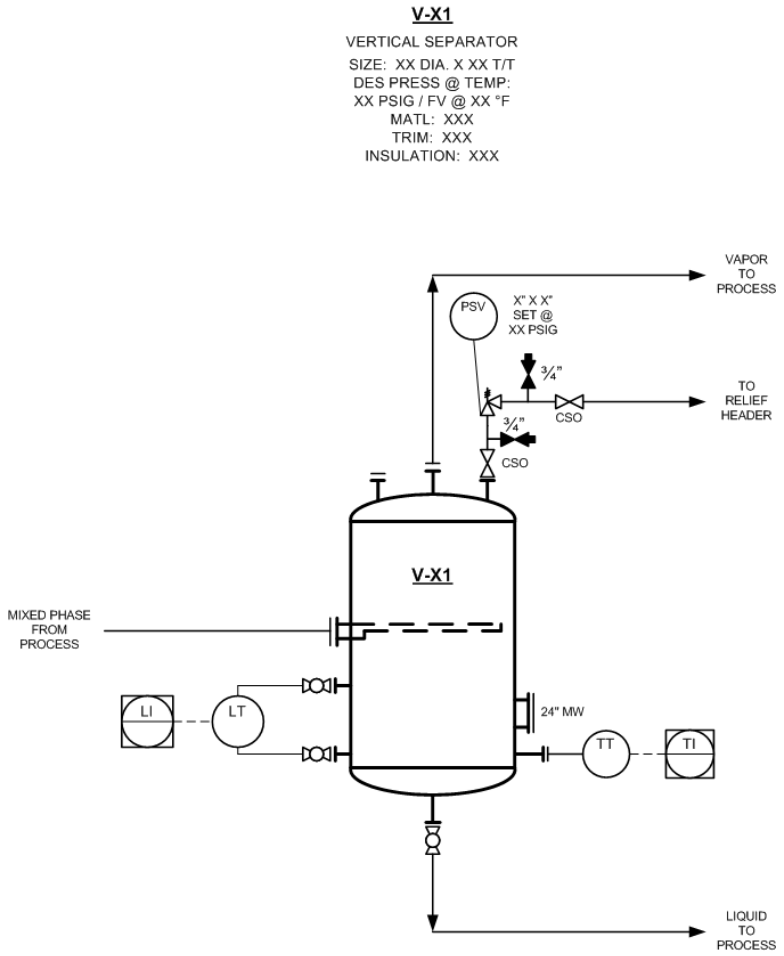
Centrifugal Pump



P-X1

CENTRIFUGAL PUMP
CAPACITY: XX GPM
HEAD: XX FT (XX PSI)
MOTOR: XX HP
MATL: XXX
TRIM: XXX
INSULATION: XXX

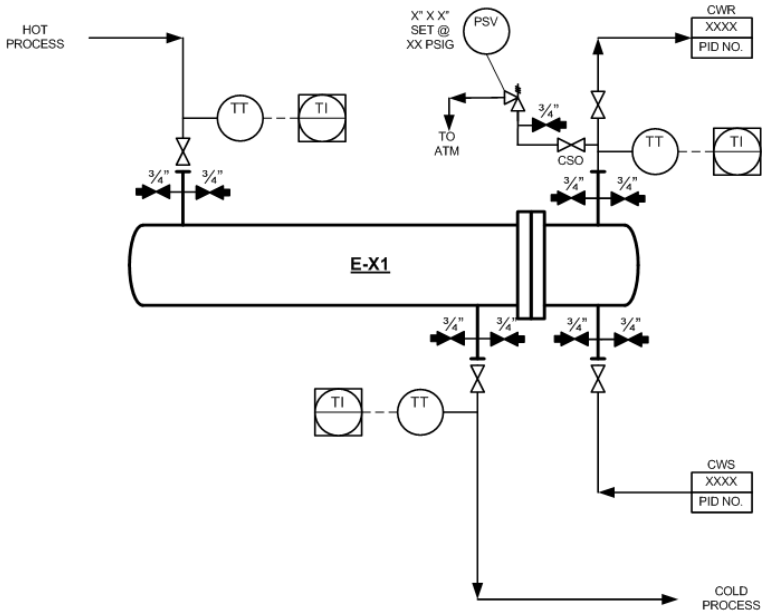
Pressure Vessel



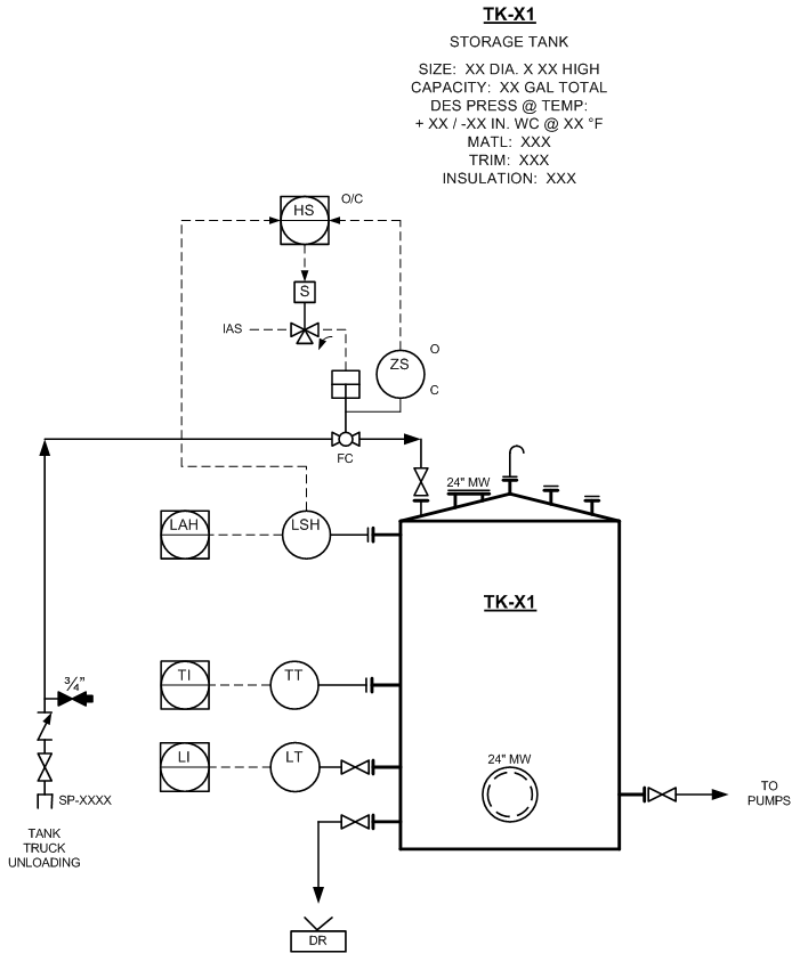
Shell & Tube Heat Exchanger

E-X1

SHELL & TUBE HEAT EXCHANGER
DUTY: XX MM BTU/HR
AREA: XX SQ. FT.
DES PRESS @ TEMP:
S: XX PSIG / FV @ XX °F
T: XX PSIG / FV @ XX °F
MATL:
S: XXX T: XXX
TRIM:
S: XXX T: XXX
INSULATION:
S: XXX T: XXX



Storage Tank



P&ID Content Checklists

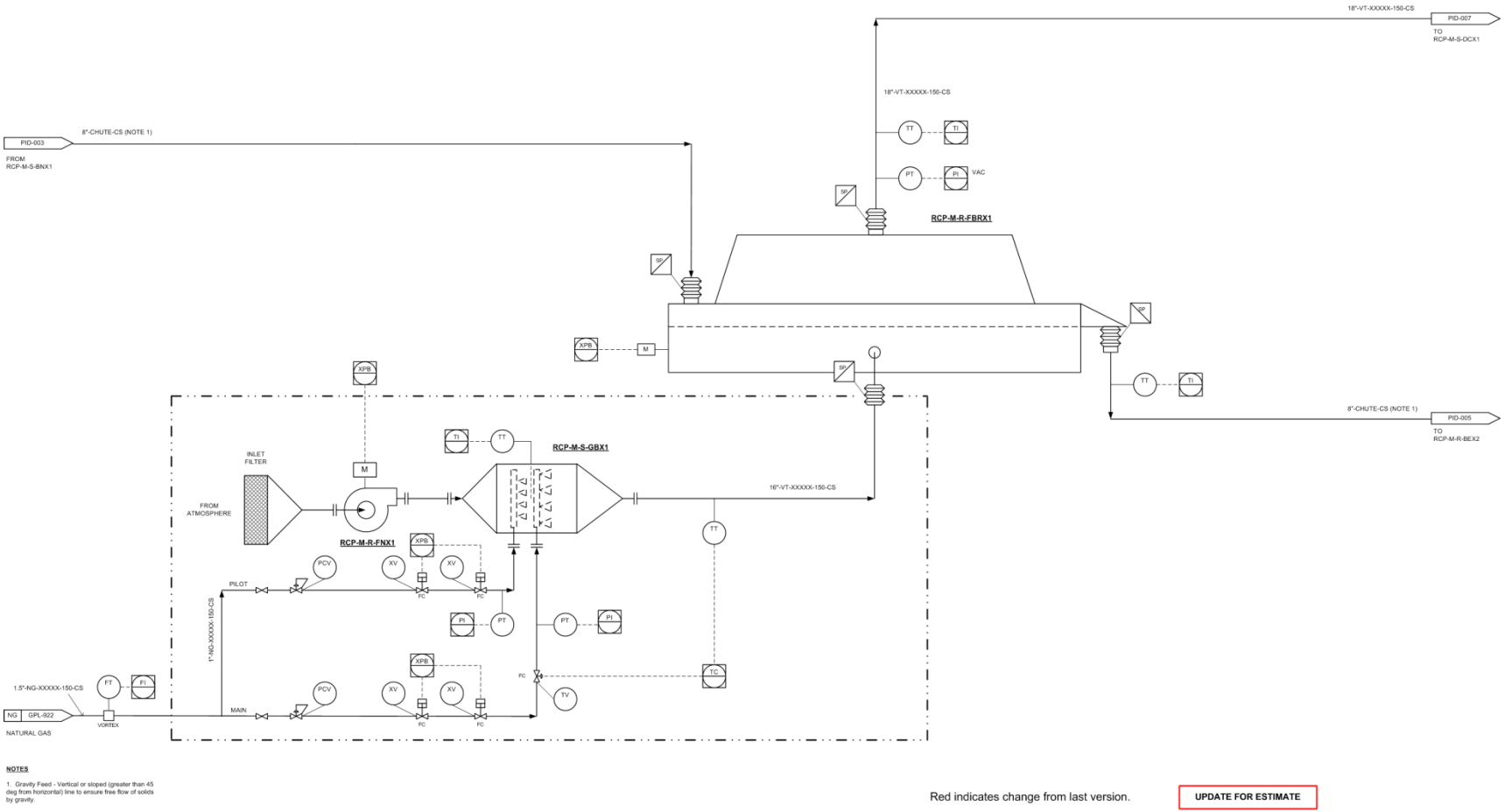
Ejectors	Instruments
Equipment Title Blocks	Pipe
Fired Heaters	Pressure Vessels
Flares	Rotating Equipment
Heat Exchangers	Storage Tanks

P&ID Content Checklist

P&ID CONTENT CHECKLIST
ROTATING EQUIPMENT

Topic	Blowers Compressors Fans	Pumps
Configuration	Centrifugal Positive Displacement Single Stage Multiple Stages Fan (Axial, Radial)	Centrifugal Positive Displacement Horizontal Vertical Parallel With Spare
Control	Local Start/Stop Remote Start/Stop Recycle Surge Protection Variable Inlet Vanes (Fans) Variable Speed Separator Levels Suction Throttling	Spare Pump Auto Start Variable Speed Discharge Pressure Gauge Minimum Flow Recycle
Driver	Electric Motor Engine Steam Turbine	Electric Motor Engine Steam Turbine
Driver – Steam Turbine	Inlet Entrainment Separator Inlet Strainer Inlet Steam Boot/Trap Lube Oil Speed Control Trip/Throttle Valve	Inlet Entrainment Separator Inlet Strainer Inlet Steam Boot/Trap Lube Oil Speed Control Trip/Throttle Valve
Externals	Inlet Separator Interstage Coolers Interstage Separators After Cooler After Separator Recycle Cooler Lube Oil System Seal Plan Silencers	Bearing Cooler Seal Plan Jacket Pulsation Dampener

Archive P&ID (Dryer)



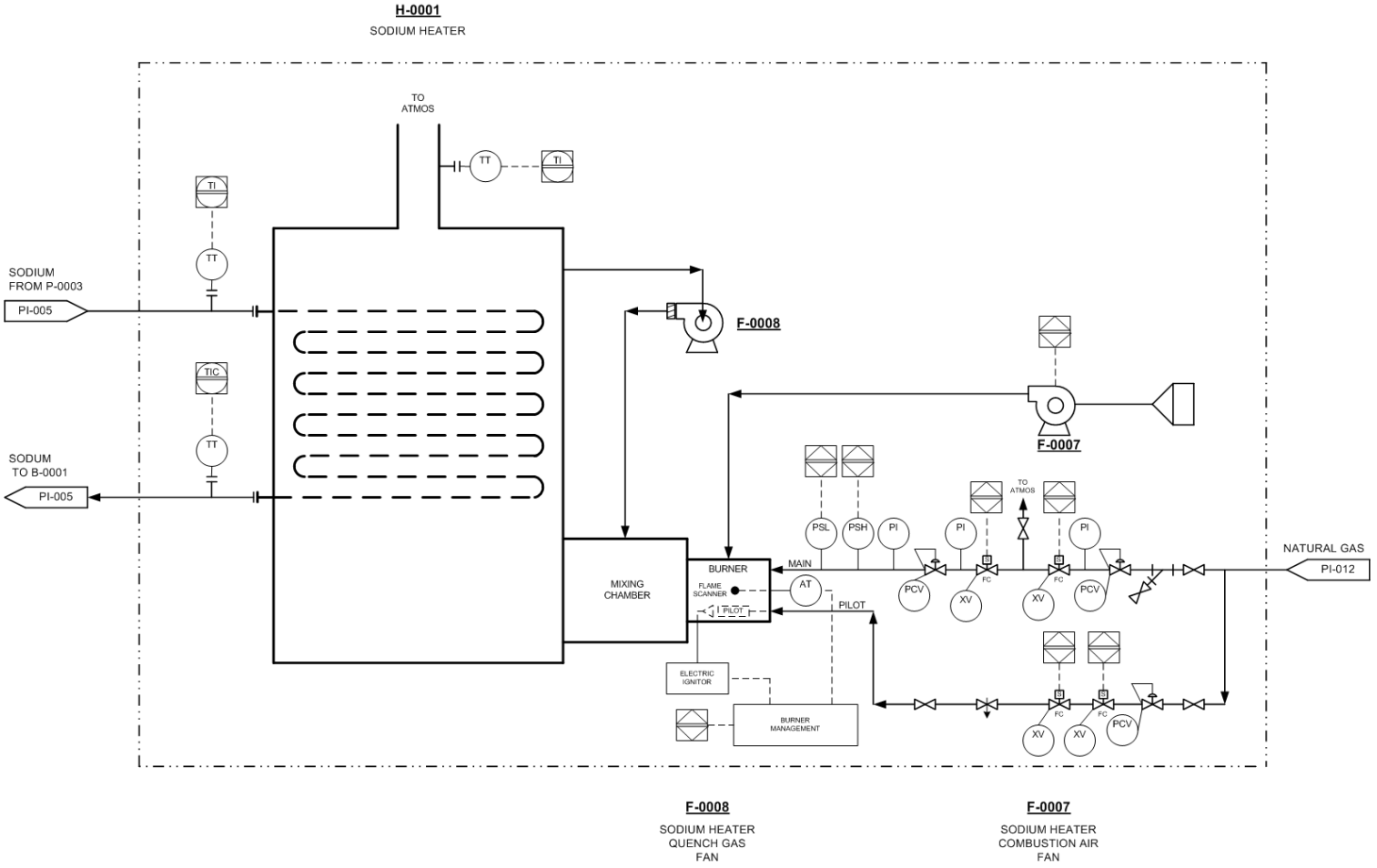
NOTES

1. Gravity Feed - Vertical or sloped (greater than 45 deg from horizontal) line to ensure free flow of solids by gravity.

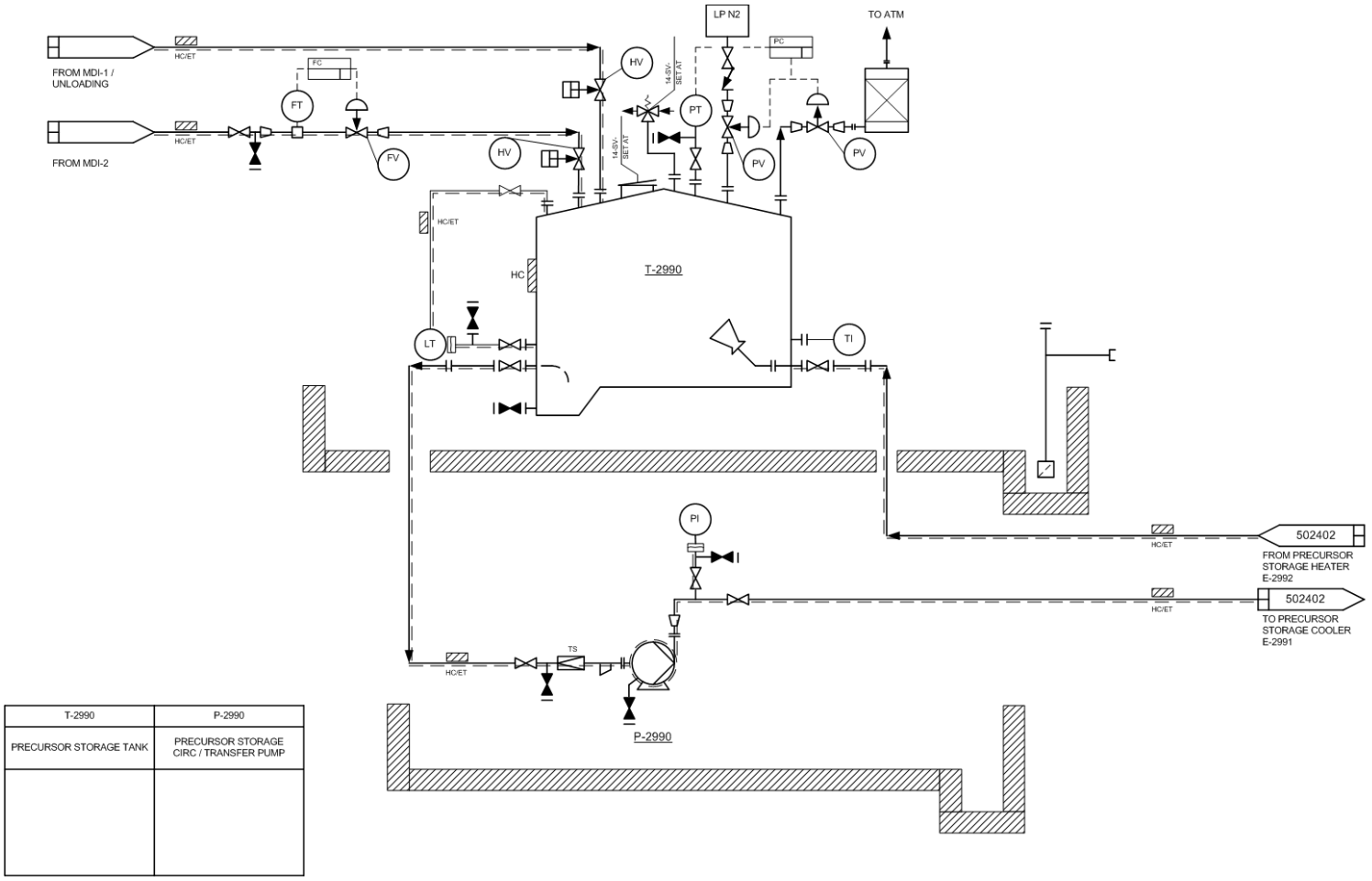
Red indicates change from last version.

UPDATE FOR ESTIMATE

Archive P&ID (Fired Heater)



Archive P&ID (Storage Tank)



T-2990	P-2990
PRECURSOR STORAGE TANK	PRECURSOR STORAGE CIRC / TRANSFER PUMP

AUDIT
For Completeness

AUDIT For Completeness

- Each Issue Of P&ID Builds On The One Before
- Use **P&ID Completeness Checklist** To Validate Completeness For Each Stage Of P&ID Development
- When Appropriate, Use HOLD Clouds To Flag Incomplete or Preliminary Information

Drawing Progression

PRELIMINARY ISSUE

- COMPLETE P&ID LEGENDS/SYMBOLS SHEETS
- EQUIPMENT WITH TAG NO. / TITLE
- PRIMARY PIPE
  - LINE SIZES
  - SERVICE CODES
  - PIPE SPECS
- KEY PROCESS VALVES
- PRIMARY INSTRUMENT LOOP ELEMENTS
- PRIMARY RELIEF VALVES

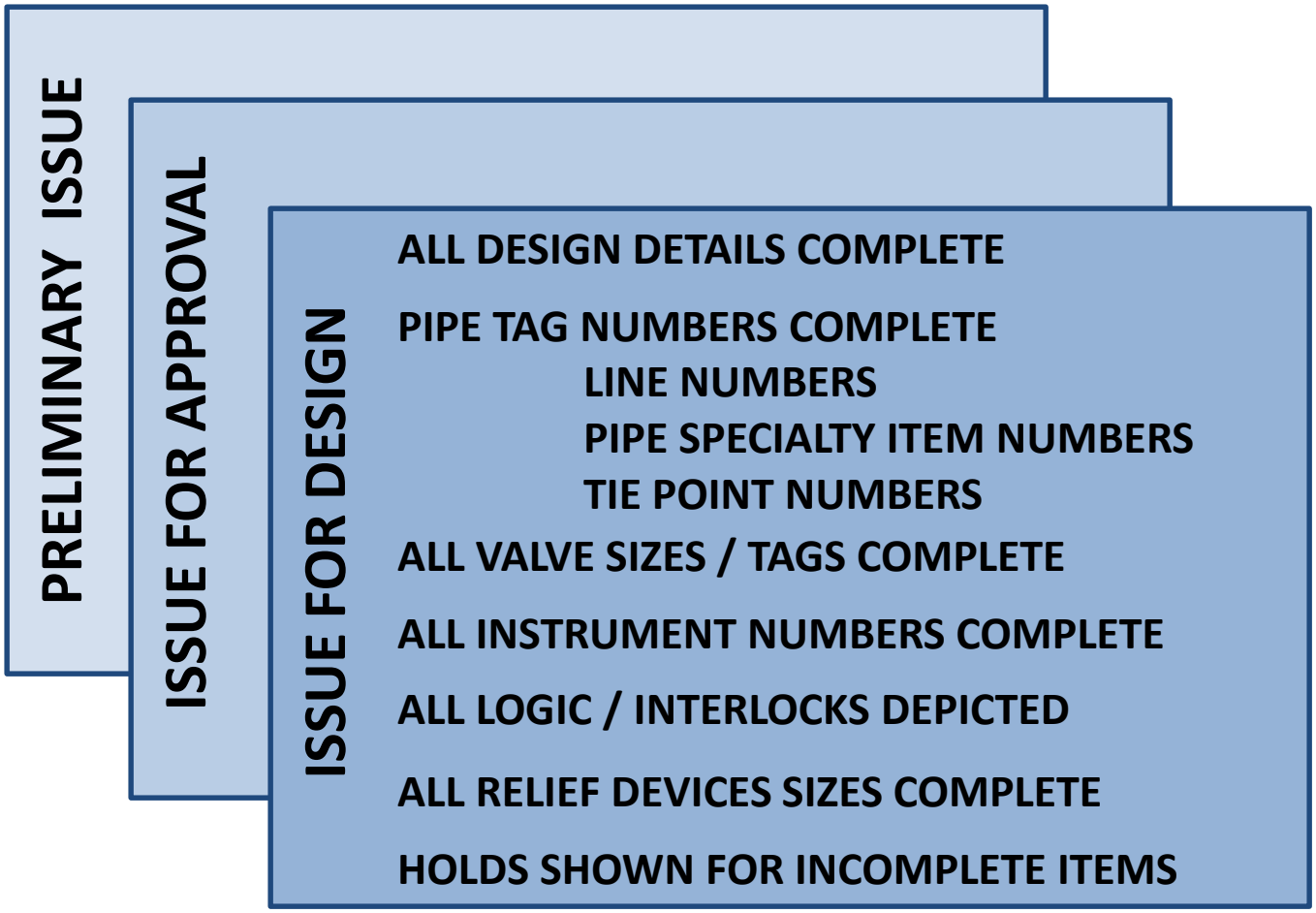
Drawing Progression

PRELIMINARY ISSUE

ISSUE FOR APPROVAL

- ALL EQUIPMENT DETAILS / TITLE BLOCKS
- ALL PIPE SHOWN (PRIMARY / SECONDARY)
  - PIPE DETAILS
  - INSULATION / TRACING
  - PIPE SPECIALTY ITEMS
- ALL VALVES SHOWN (TYPES IDENTIFIED)
- COMPLETE INSTRUMENT LOOPS
- MOTOR CONTROLS
- ALL RELIEF VALVES SHOWN
- ALL SPECIAL NOTATIONS COMPLETE

Drawing Progression



Completeness Checklist

P&ID COMPLETENESS CHECKLIST

Item	Preliminary Issue	Issue for Approval	Issue for Design	Issue for Construction
EQUIPMENT				
Number of Items	X	O	O	O
Name of Items	X	O	O	O
Type/Configuration	X	O	O	O
Spare Item Requirements	X	O	O	O
Data/Sizing/Design Press. & Temp.		X	O	O
Driver (If Applicable)		X	O	O
HP/Energy Consumption		X	O	O
Nozzle Sizes		X	O	O
Insulation/Tracing		X	O	O
Vendor Data (If Vendor Designed)			X	O
Seal Arrangements (If Required)			X	O
Packaged Equipment Details				X
Vendor Detailed Drawings				X
PIPING				
Line Sizes	X	O	O	O
Line Specifications	X	O	O	O
Flow Arrows/Continuations	X	O	O	O
Secondary Flows		X	O	O
Specification Breaks		X	O	O
Insulation/Tracing		X	O	O
Sample Points		X	O	O
Reducers		X	O	O
Vent/Sewer Designations		X	O	O
Line Numbers (by Piping)			X	O

CHECK
For Consistency

CHECK For Consistency

- Perform Stream Arrow Cross-Checks Between P&IDs
- Conduct Process Team Reviews
- Conduct Interdisciplinary Team Reviews
- Implement Team Reviews Per **P&ID Quality Assurance Matrix**

P&ID Quality Assurance Matrix

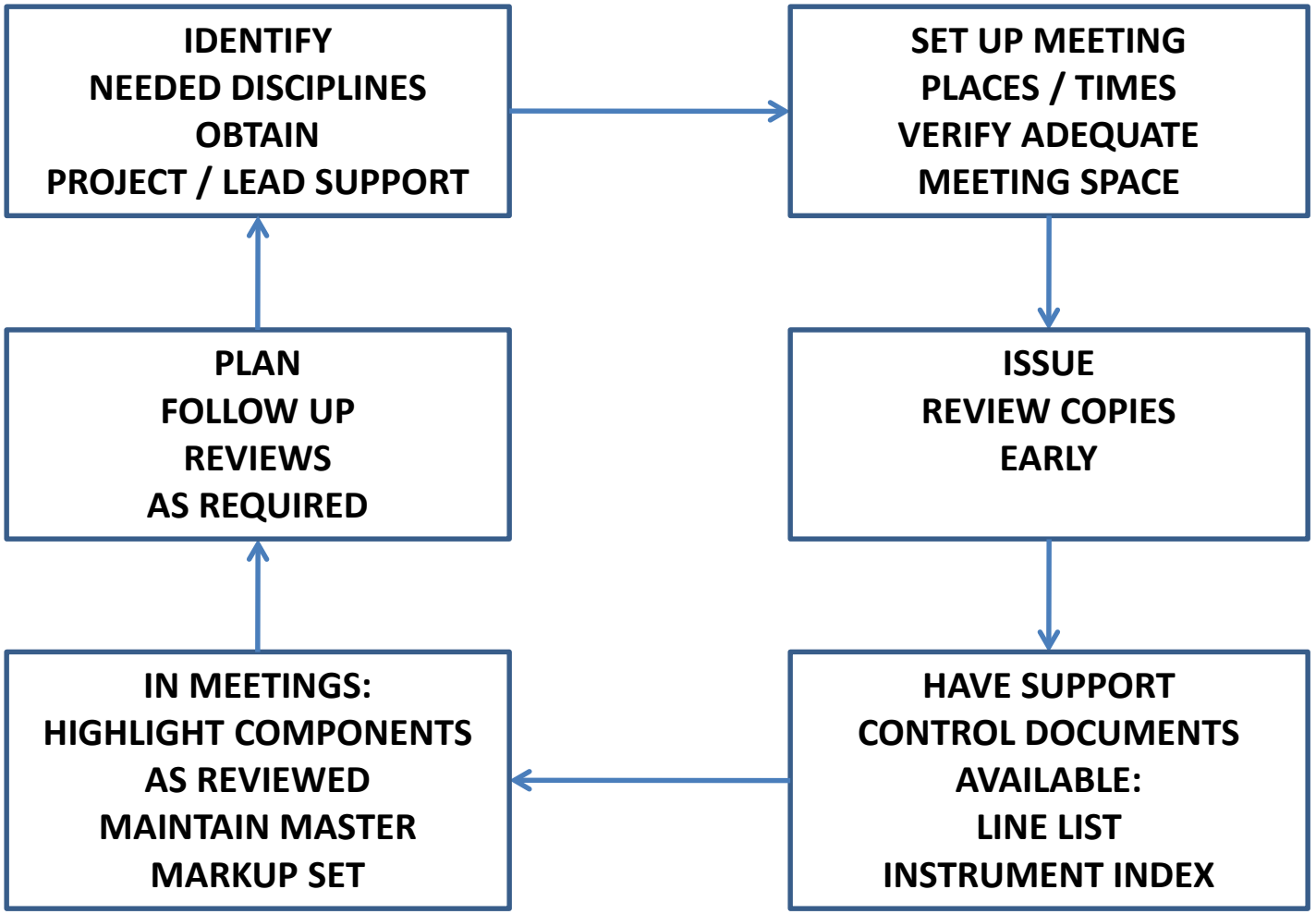
P&ID QUALITY ASSURANCE MATRIX
UPDATED: RBT/09-29-10

Phase	Preliminary Issue	Issue for Approval (IFA)	Issue for Design (IFD)	Issue for Consti
Design Input	P&ID Legend & Symbols Flow Sheet Drafting And Layout CADD Standards See Preliminary Issue Related Documents On P&ID Completeness Checklist	Preliminary Drawings With Client And Discipline Comments See Preliminary Issue Related Documents On P&ID Completeness Checklist	IFA Drawings With Client And Discipline Comments See IFA Related Documents On P&ID Completeness Checklist	IFD Drawings With Design Final Vendor Data See IFD Related D Checklist – With A Design
Design Output	See P&ID Completeness Checklist	See P&ID Completeness Checklist	See P&ID Completeness Checklist	See P&ID Comple
Design Review Before Issue	Process Internal Development And Review Process Back Checking Of Drafting Pickups Preliminary Interdisciplinary Review	Process Internal Development And Review Process Back Checking Of Drafting Pickups Formal Interdisciplinary Review Formal Client Review Of IFA Drawings	Process Internal Follow Up To IFA Comments Process Back Checking Of Drafting Pickups	Ongoing Review C
Design Verification Before Issue	Lead Process Engineer Approval Project Engineer Approval	Lead Process Engineer Approval Project Engineer Approval	Lead Process Engineer Approval Project Engineer Approval Client Approval	Project Engineer A Client Approval
Design Changes After Issue	Changes occurring after preliminary issue will be normal design development and resolution of comments returned by client. These changes will be reflected in the next sequential issue of the drawings, typically IFA.	Changes occurring after IFA will be normal design development and resolution of comments from formal client review. These changes will be reflected in the next sequential issue of the documents, typically IFD.	Changes after IFD are handled by the design change management procedure where changes are marked on a master set of P&IDs and documented in a design change log. The changes are accumulated and are reflected on the next sequential issue of the documents. Process Hazards Analysis (PHA) is often done shortly after the IFD issue and is based on that P&ID issue. If the PHA is held later in the project, then a special issue of the P&IDs, incorporating all changes accumulated to date, is made (Issued for PHA) to serve as the basis for PHA. After PHA, changes are handled by the formal management of change (MOC) procedure where	Changes after IFC management and procedure.

P&ID Process Team Review

- If More Than One Team Member Is Assigned P&ID Development, Process Lead Should Routinely Review All Drawings For **Presentation Consistency**
- Use Peer Review For **Completeness Checks**
- Use **Expertise Review** For Complex Or Specialty Systems

P&ID Interdisciplinary Team Review



Summary

Locate The **ROAD MAP**	P&ID Legends & Symbols
Standardize On **FORMAT**	Arrange Drawing Building Blocks Effectively
LAYOUT For Clarity	Don't Crowd P&IDs
ANALYZE Content for Accuracy	Develop Standard Configurations & Duplicate
AUDIT For Completeness	Use P&ID Completeness Checklist
CHECK For Consistency	Use Interdisciplinary Review Teams