Piping & Instrument Diagrams

Barry M Barkel PE

Communication for Engineers

- Verbal
  - Assignments, Instructions, updates
- Written
  - Reports, Procedures, Specifications
- Mathematical
  - Calculations, data, Performance statistics
- Symbolic
  - Designs, Process Documentation

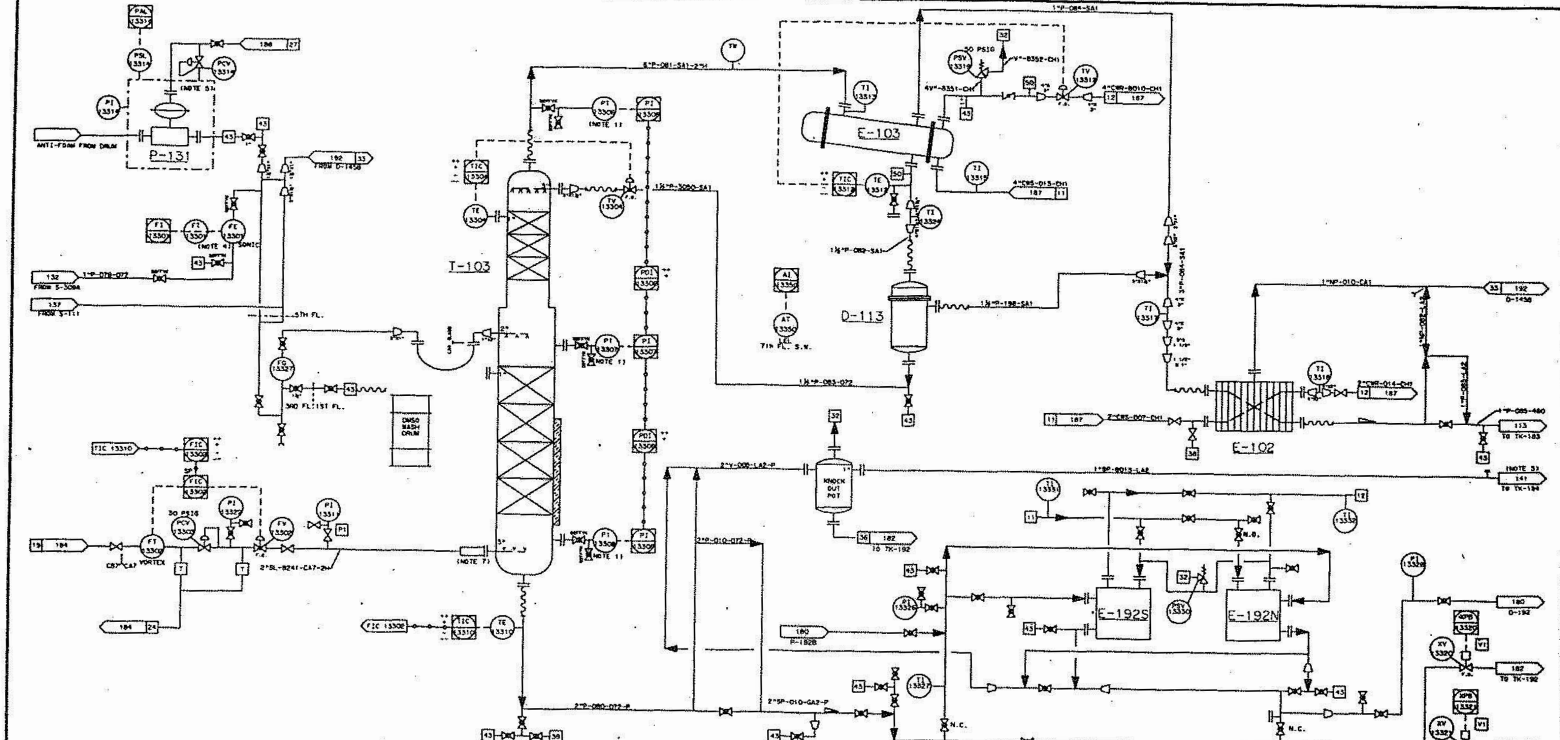
Drawings are Engineering's

INTERNATIONAL LANGUAGE

engineers all over the world can understand them

TYPES of DRAWINGS

- Process Flow Diagrams: What a Process Does
- Piping & Instrument Diagrams: How it works
- Layout Drawings: How it looks
- Mechanical Drawings: |
  |
  | How to build it
  Construction Drawings: |



LEGEND					
COOLING WATER SUPPLY	STEAM	AIR-PLANT	SEWER-SANITARY	QUICK DISCONNECT
COOLING WATER RETURN	STEAM	AIR-INSTRUMENT	SEWER-PROCESS	HOT OIL SUPPLY
WATER-DEMINERALIZED	STEAM	NATURAL GAS	SEWER-NONCONTACT	HOT OIL RETURN
WATER-COAGULATED	CHILLED WATER SUPPLY	NITROGEN	DRAIN	DEIONIZED H_2O
WATER-CITY	CHILLED WATER RETURN	BLEED	SAMPLE	TEMPERED H_2O SUPPLY
WATER-FIRE PROTECTION	CONDENSATE (HIGH PRESS)	TO ATMOSPHERE	SAMPLE WITH COOLER	TEMPERED H_2O RETURN
WATER-RIVER	CONDENSATE (LOW PRESS)	NITROGEN PADDING	PUMPOUT	VACUUM
DRY DISCONNECT	ROOM AIR	EMERGENCY VENT	HOSE CONNECTION	PRESSURE TAP PLUGGED

NOTES

1. SPECIALTY CERAMIC PRESSURE TRANSMITTER.
2.
3. FUSES INTO LINE FROM E-108 BEFORE FLOWING TO TK-194.
4. PROVIDE LIQUID SEAL LEG WITH FE 13301 LOCATED IN THE VERTICAL RISER.
5. P-131 IS LOCATED INSIDE A PLASTIC ENCLOSURE.
6. ALARMS WHEN OIL IS PRESENT IN LINE.
7. STEAM SPARGER IS SCH. 40 HASTALLOY W/GLASS NOZZLE AND C.S. CONNECTION.

ITEM NO.	P-131					
SERVICE	ANTI-FOAM PUMP					
TEMP. °F	---					
SG @ P.T.	---					
DES. GPM	---					
DES. DIFF. PSI	---					
MATERIAL	---					
HORSEPOWER	---					

ITEM NO.	E-102	E-103	E-192N/S		
SERVICE	METHANOL SUBCOOLER	METHANOL STRIPPER CONDENSER	COOLER		
SH. DES. PSIG/ °F	75/113	100/212			
TU. DES. PSIG/°F	75/113	75/200	75/212		
SURFACE S.F.	57	334	60		
SHELL MATERIAL	GRAPHITE	C.S.			
TUBE MATERIAL	GRAPHITE	304 S.S.	TEFFLON		
INSULATION	---	---			

ITEM NO.	D-113	T-103			
SERVICE	METHANOL REFLEX DRUM	METHANOL STRIPPER			
SIZE DIA x T.T.	1'-0"X2'-0"	1'-6"X40'-0"			
DES. PSIG/ °F	---	---			
OP. PSIG/ °F	6"W.C./149	6"W.C./212			
CAP FULL	20 LITER	---			
MATERIAL	GLASS	GLASS			
INSULATION	NONE	8			

[redacted]

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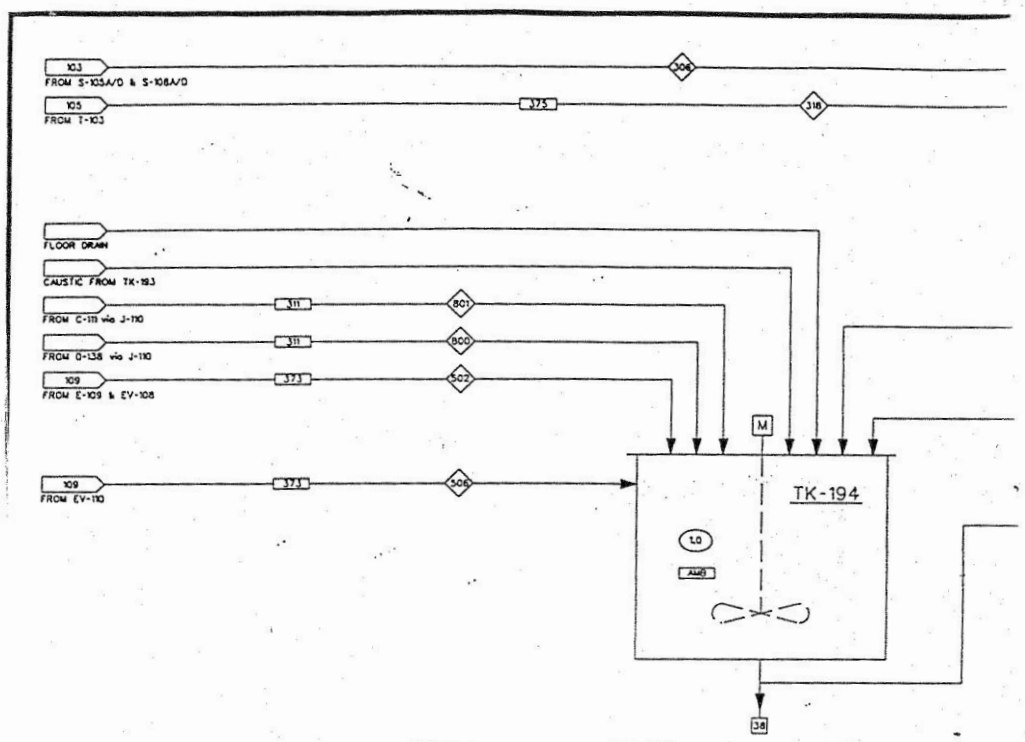
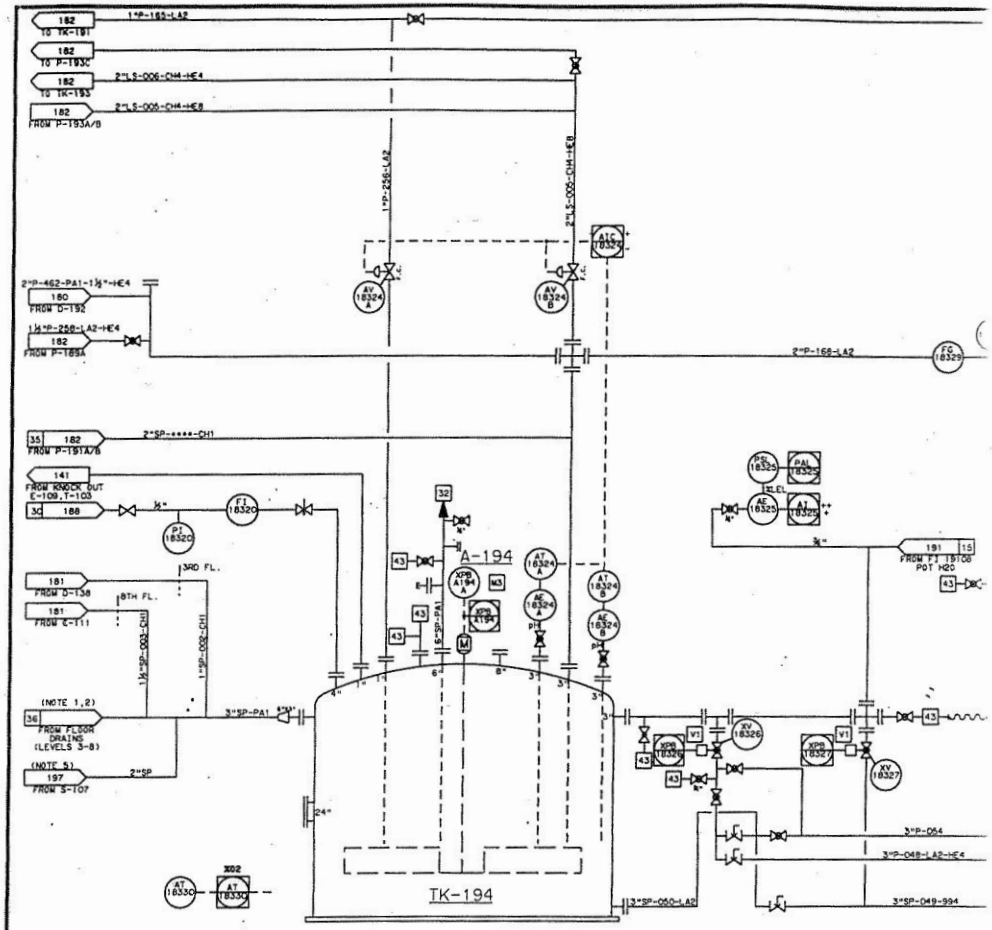


STREAM IDENTIFICATION NO.		306		316		502		506		800		801			
STREAM DESCRIPTION		COMBINED $ZnCl_2/H_2O$		T-10.3 METHANOL BOTTOMS		E-109 CONDENSATE		EV-110 DISTILLATE		HOTWELL D-138 TO TK-194		C-111 TO TK-194			
#	COMPONENTS	FORMULA	KG/HR	WT %	KG/HR	WT %	KG/HR	WT %	KG/HR	WT %	KG/HR	WT %	KG/HR	WT %	KG/HR	WT %
4	ZINC CHLORIDE	$ZnCl_2$	31.4	25.5	TRACE											
1	WATER	H_2O	81.4	66.2	1153.2	98.7					125.5	94.3	13.04	97.2		
7	DL-α-TOCOPHEROL	$C_{29}H_{50}O_2$			0.3	.02										
4	TRIDECYLAMINE HYDROCHLORIDE	$C_{13}H_{29}N$			4.3	0.4										
-	IMPURITIES	----	4.1	3.3	5.0	0.4					0.01	0.0				
5	HYDROGEN CHLORIDE	HCl	8.1	5.0	2.0	0.4										
1	METHANOL	CH_3OH			1.0	0.1										
2	HEPTANE	C_7H_{16}	TRACE				1.5	2.6								
	SODIUM HYDROXIDE	NaOH														
	ACETIC ANHYDRIDE	$(CH_3CO)_2O$					13.7	23.5			0.44	.33	0.02	.2		
2	VITAMIN E ACETATE	$C_{31}H_{52}O_3$					TRACE		TRACE		0.01	0.0				
	ACETIC ACID	CH_3COOH					43.0	73.9			6.84	5.2	0.36	2.6		
	TOTAL KG/HR		123		1165.9		58.2		TRACE		132.81		13.42			
	TOTAL MOLS															
	PHASE		LIQUID		LIQUID		LIQUID		LIQUID		LIQUID		LIQUID			
	WT. % SOLIDS		24.7		----		----		----		----		----			
	VISCOSITY (mPa-s or cp)		1.0		.9		.01		7		.9		.9			
	DENSITY (KG/M³) (NOTES 1 & 2)		~1200		~1000		1042		870		1002		1001			
	MOLECULAR WEIGHT (KG/KGMOL)		24.2		18.7		67.2		472		18.7		18.4			
	FLOW RATE @ P.T. (M³/HR) (NOTE 3)		0.102		1.17		.08		.007		0.13		0.01			



LEGEND					
11 COOLING WATER SUPPLY	18 STEAM	27 AIR-PLANT	53 SEWER-SANITARY	43 QUICK DISCONNECT	NOTE
12 COOLING WATER RETURN	20 STEAM	28 AIR-INSTRUMENT	54 SEWER-PROCESS	44 HOT OIL SUPPLY	1. SELE
13 WATER-DEMINERALIZED	21 STEAM	29 NATURAL GAS	57 SEWER-NONCONTACT	45 HOT OIL RETURN	2. TRU
14 WATER-COAGULATED	22 CHILLED WATER SUPPLY	30 NITROGEN	58 DRAIN	46 DEIONIZED H_2O	3. XS (
15 WATER-CITY	23 CHILLED WATER RETURN	31 BLEED	59 SAMPLE	47 TEMPERED H_2O SUPPLY	4.
16 WATER-FIRE PROTECTION	24 CONDENSATE(HIGH PRESS)	32 TO ATMOSPHERE	40 SAMPLE WITH COOLER	48 TEMPERED H_2O RETURN	5. S-10
17 WATER-RIVER	25 CONDENSATE (LOW PRESS)	33 NITROGEN PADDING	41 PUMPOUT	49 VACUUM	6. PSV
18 DRY DISCONNECT	26 ROOM AIR	34 EMERGENCY VENT	42 HOSE CONNECTION	50 PRESSURE TAP PLUGGED	

ITEM NO.	C-191	P-190	P-296			ITEM NO.					
SERVICE	ZINC FILTER VACUUM PUMP	FILTRATE PUMP	HCL TOTE PUMP			SERVICE					
TEMP. °F	AMBIENT	AMBIENT	---			SH. DES. PSIG/ °F					
SG @ P.T.	---	1.05	---			TU. DES. PSIG/°F					
DES. GPM	280 CFM	20	---			SURFACE S.F.					
DES. DIFF. PSI	20" Hg	---	---			SHELL MATERIAL					
MATERIAL	---	SI-Fe	---			TUBE MATERIAL					
HORSEPOWER	20	8	---			INSULATION					

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Uses of P&IDs

- Develop Operational methodology
- Develop Safety Philosophy and Design
- Develop Control Philosophy
- Basis for Control Programming
- Communication Document for Project

Uses of P&IDs

- Serves as Design Basis for:
  - Equipment Design
  - Piping Design
  - Estimating
  - Purchasing
- Used to evaluate construction progress
- Training basis for Operational Personnel

Characteristics of P&IDs

- Grouped by specific sections of the process
- Schematic; NOT a scaled layout
- Clear; uncluttered
- Systematic; uniform
- Usually confidential
- Revised often with Revisons clearly identified

Elements of a P&ID

- Equipment & valves identified
- Instrumentation type & location identified
- Path between instruments & control devices indicated
- Piping size and type identified for all lines

Identification of Equipment

- Identification by type

  w/ specific code designation..ie TK

  w/ a specific standardized shape
- Identification by number

  w/ specific item number…ie TK 101
- Identification by name

  w/ what the unit is called.. ie methanol tank

5.5 Equipment Identification

5.5.1 Equipment shall be identified with an classification code letter and a das followed by a number The equipment code and number shall be shown adjacent to the equipment it designates on the PFD.

5.5.2 Equipment Classification

Code	Equipment
A	Agitators, Mixers
BL	Blowers, Fans
C	Compressors
CF	Centrifuges
CT	Cooling Towers
CV	Conveyers
CY	Cyclones
D	Drums, (surge vessels, KO pots)
E	Heat Exchangers
F	Filters
G	Grinders, Mills, Crushers
H	Direct Fired Heaters
J	Jets, Ejectors, Eductors
M	Motors
P	Pumps
R	Reactors
RU	Refrigeration Units
S	Separators, Decanters
SC	Screens
SM	Static Mixers
T	Towers (distillation, extraction, scrubbing)
TK	Storage Tank
VP	Vacuum Pump
X	Misc. & Special Equip.

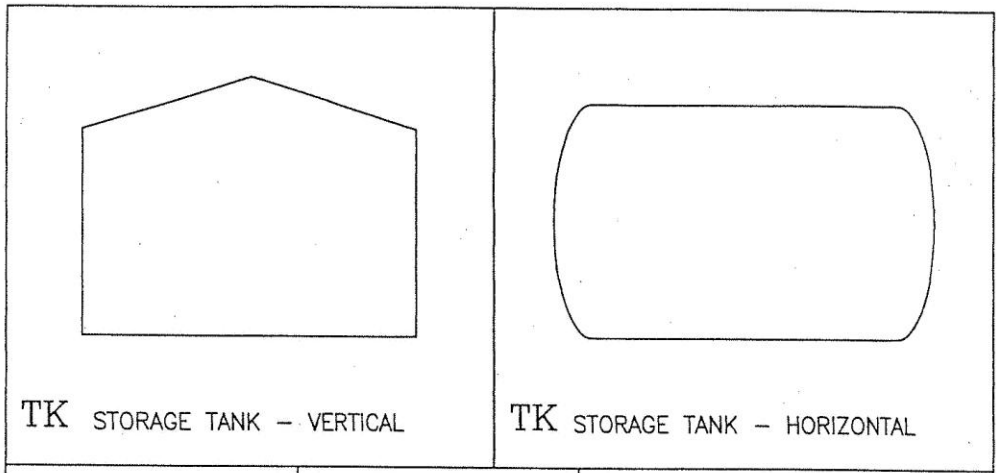
5.5..3. Equipment Numbers

Each identifiable item of equipment shall be assigned a 2 or 3 digit number. Items numbers may be grouped by division of the process

i.e. Reaction ----100 to 199
Distillation- 200 to 299
Storage -------300 to 399

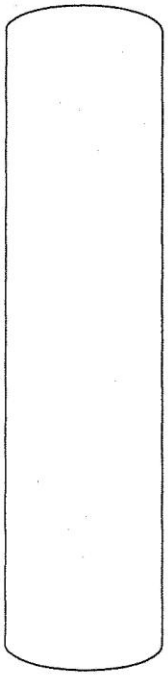
5.6. Equipment Symbols

See Attached Figures

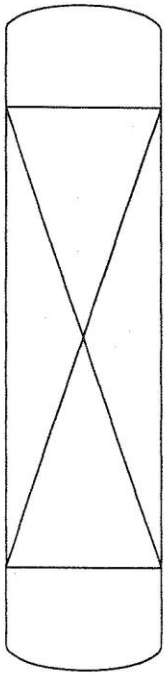


TK STORAGE TANK – VERTICAL

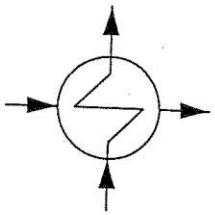
TK STORAGE TANK – HORIZONTAL



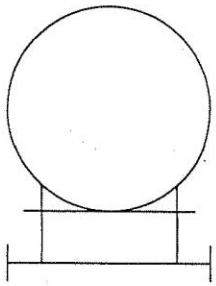
T COLUMN /TOWER



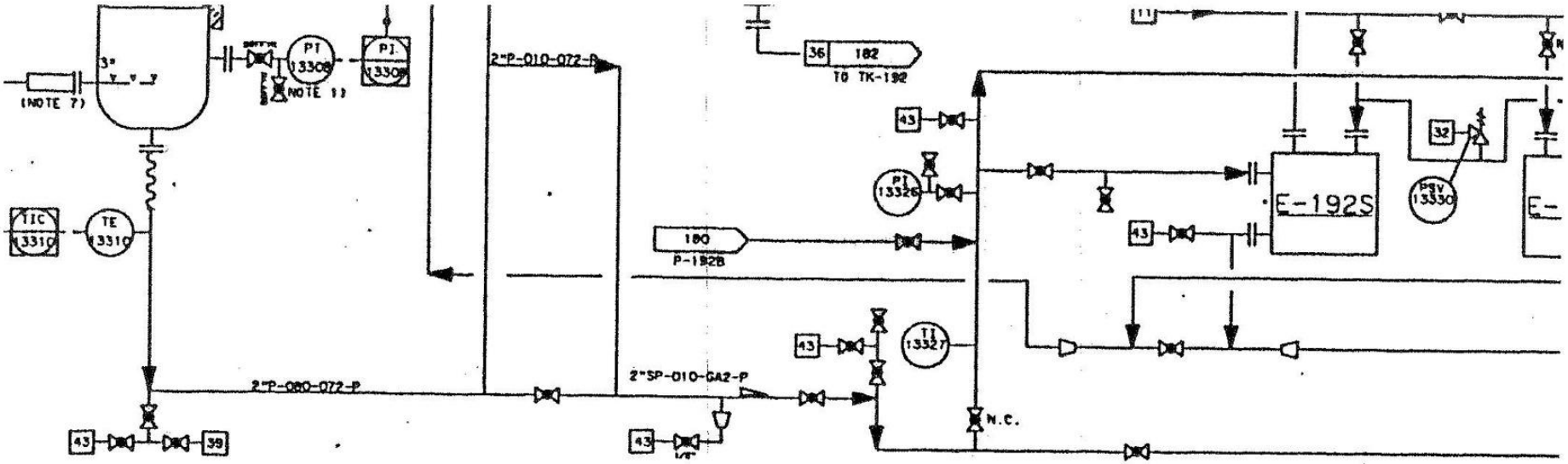
T PLACKED COLUMN /TOWER



E EXCHANGERS – ALL TYPES



T TANK CAR



35 SEWER-SANITARY	43 QUICK DISCONNECT
36 SEWER-PROCESS	44 HOT OIL SUPPLY
37 SEWER-NONCONTACT	45 HOT OIL RETURN
38 DRAIN	46 DEIONIZED H_2O
39 SAMPLE	47 TEMPERED H_2O SUPPLY
40 SAMPLE WITH COOLER	48 TEMPERED H_2O RETURN
41 PUMPOUT	49 VACUUM
42 HOSE CONNECTION	50 PRESSURE TAP PLUGGED

NOTES

1. SPECIALTY CERAMIC PRESSURE TRANSMITTER.
2.
3. FUSES INTO LINE FROM E-109 BEFORE FLOWING TO TK-194.
4. PROVIDE LIQUID SEAL LEG WITH FE 13301 LOCATED IN THE VERTICAL RISER.
5. P-131 IS LOCATED INSIDE A PLASTIC ENCLOSURE.
6. ALARMS WHEN OIL IS PRESENT IN LINE.
7. STEAM SPARGER IS SCH. 40 HASTALLOY W/GLASS NOZZLE AND C.S. CONNECTION.

	E-102	E-103	E-192N/S			ITEM NO.	D-113	T-103			
	METHANOL SUBCOOLER	METHANOL STRIPPER CONDENSER	COOLER			SERVICE	METHANOL REFLEX DRUM	METHANOL STRIPPER			
°F	75/113	100/212				SIZE DIA x T.T.	1'-0"X2'-0"	1'-6"X40'-0"			
°F	75/113	75/200	75/212			DES. PSIG/ °F	---	---			
	57	334	60			OP. PSIG/ °F	8"W.C./149	8"W.C./212			
	GRAPHITE	C.S.				CAP FULL	20 LITER	---			
	GRAPHITE	304 S.S.	TEFFLON			MATERIAL	GLASS	GLASS			
	---	---				INSULATION	NONE	8			

Valve Identification

- Identification by type

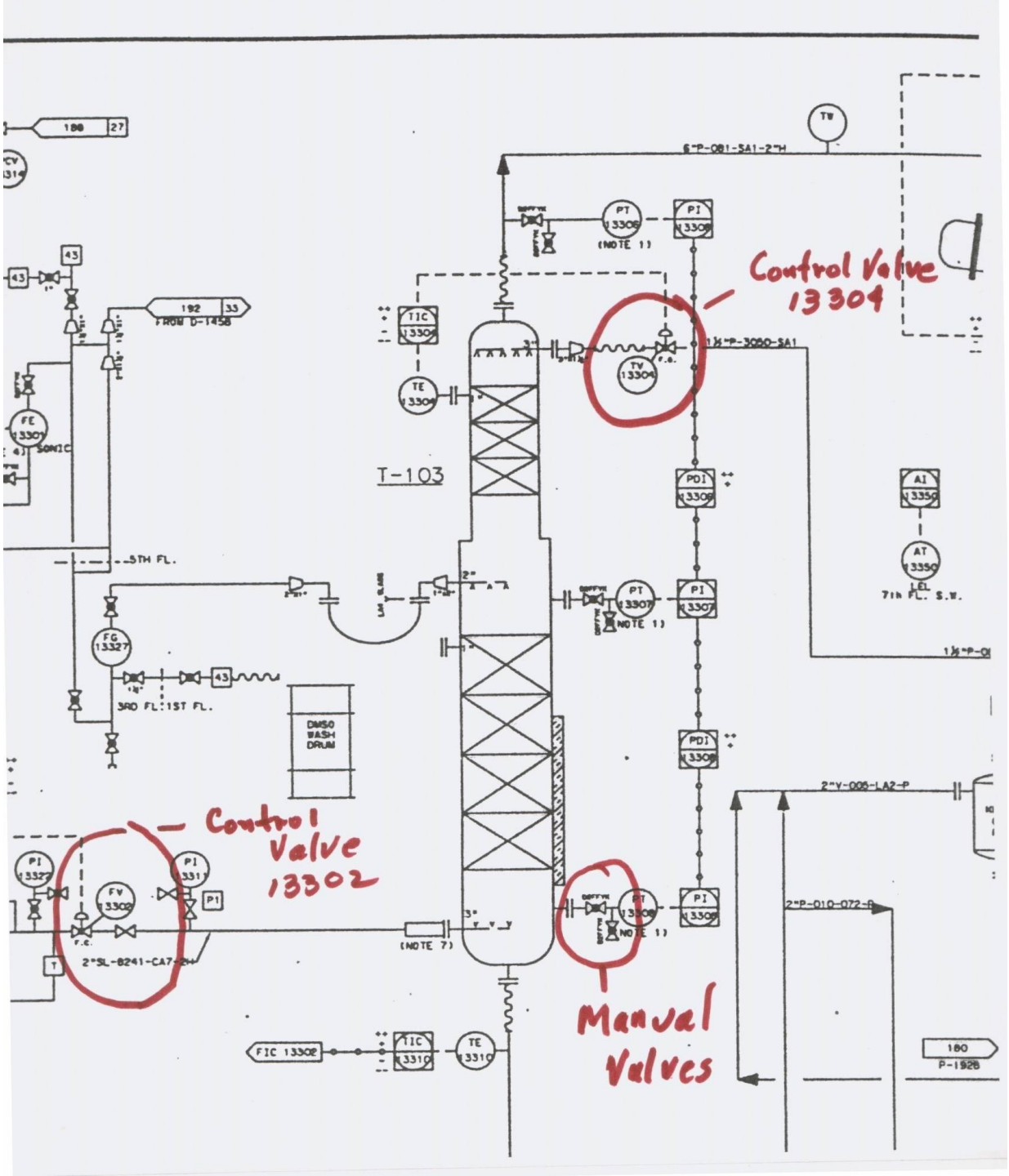
Technical Standard

Date

PIPING & INSTRUMENT DIAGRAM

 GATE VALVE	 GLOBE VALVE	 PLUG VALVE	 BALL VALVE
 DIAPHRAGM VALVE	 NEEDLE VALVE	 QUICK OPENING VALVE	 CHAIN OPERATED VALVE
 Y-VALVE	 ANGLE VALVE	 FLUSH BOTTOM TANK VALVE	 BUTTERFLY VALVE
 BEVEL GEAR OPERATED VALVE	 3-WAY VALVE	 BLEEDPORT BALL VALVE	 BLEEDPORT PLUG VALVE
 VEE BALL VALVE	 4-WAY VALVE	 CHECK VALVE	 RELIEF VALVE
 RUPTURE DISC	 DAMPER VALVE	 NON-RETURN VALVE	 PINCH VALVE
 SAMPLE CONNECTION	PIV  POST INDICATOR VALVE	EF  EXCESS FLOW VALVE	 FOOT VALVE
CSO  CAR SEAL OPEN	CSC  CAR SEAL CLOSED	 JACKETED VALVE	

VALVE SYMBOLS


Control Valve 13304
Control Valve 13302
Manual Valves
T-103
DMSO WASH DRUM
5TH FL.
3RD FL.
1ST FL.
FROM D-1458
SONIC
(NOTE 1)
(NOTE 7)
6"P-081-5A1-2"H
1½"P-3080-5A1
2"V-005-LA2-P
2"P-010-072-P
2"SL-8241-CA7-2"H
FIC 13302
P-1928

Instruments

- Instruments may be: Indicators
  or Part of a control system
- Instruments often have several components:
  sensing elements
  transmitters
  control elements

Some Instrument Designations

P = pressure

T= Temperature

F = Flow

L = Level

I = indicator

C = controller

S = switch

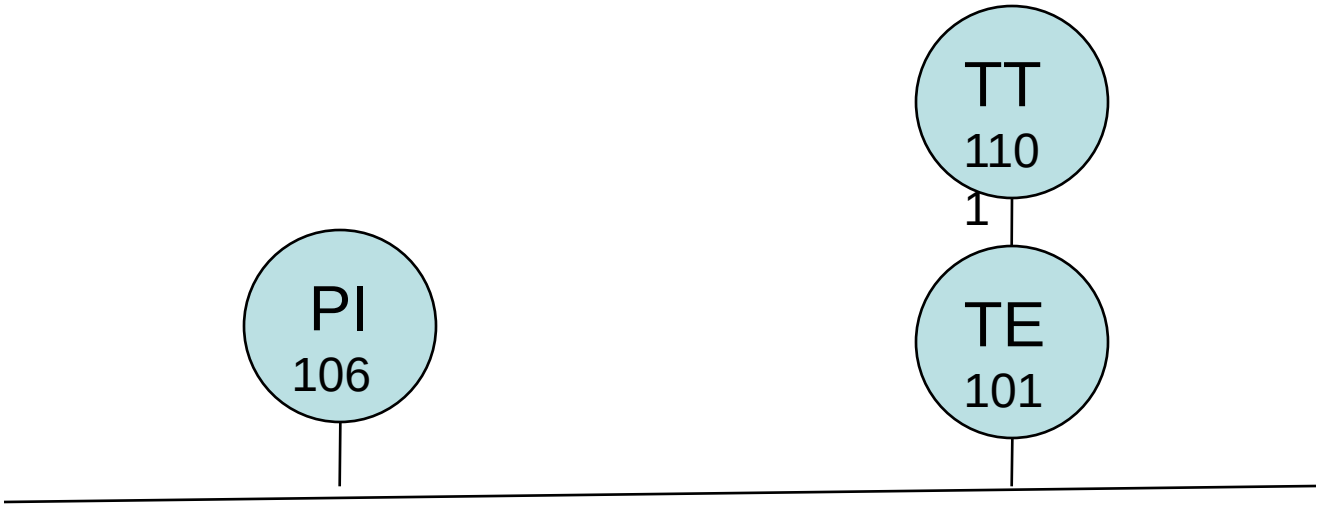
E = element

T = transmitter

G = gage

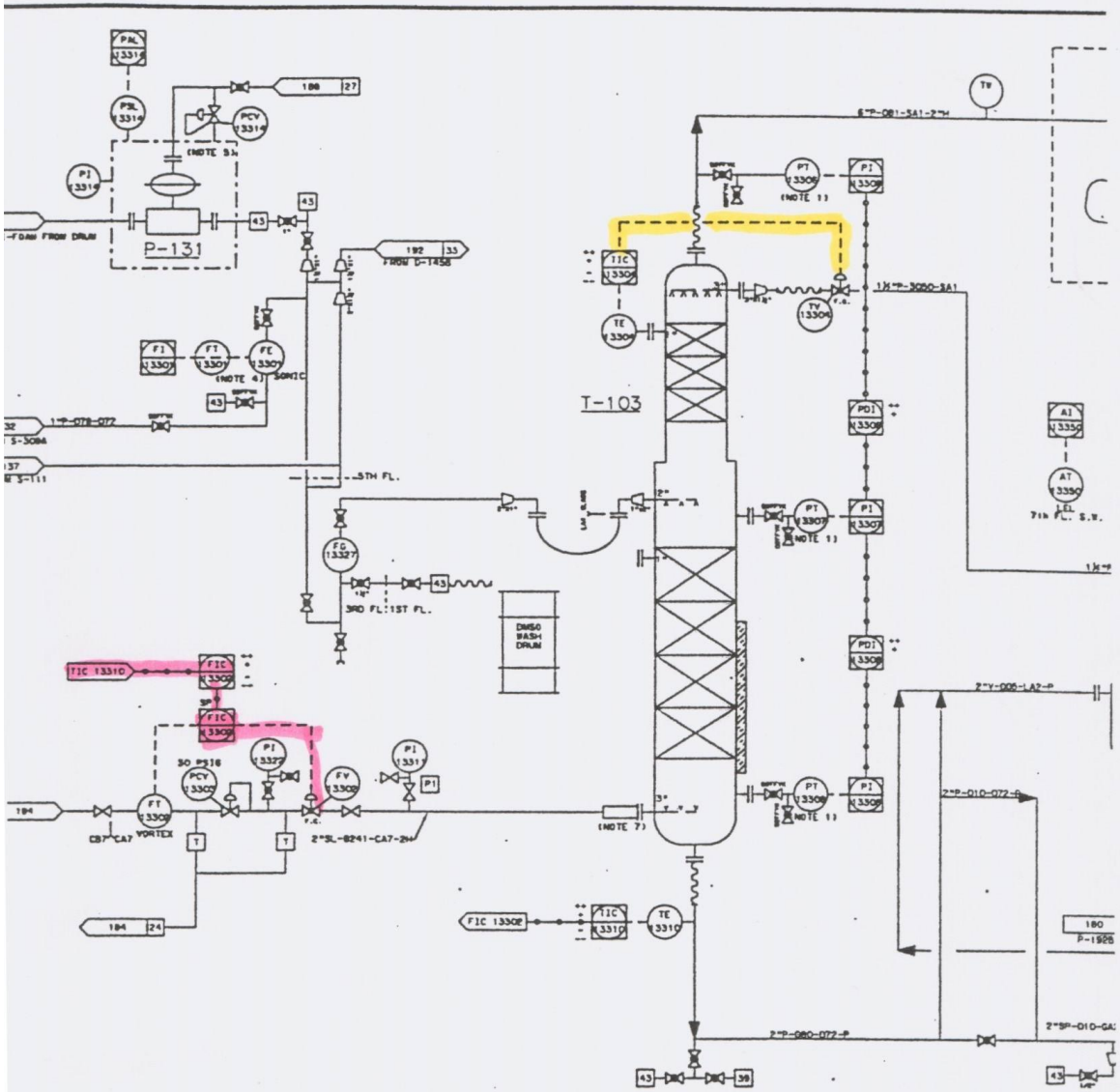
- ISA designations usually used

Instrument Configuration



Control Paths

- Hardwired
- “Computer program”



OLING WATER SUPPLY	21 STEAM	27 AIR-PLANT	33 SEWER-SANITARY	43 QUICK DISCONNECT
OLING WATER RETURN	22 STEAM	28 AIR-INSTRUMENT	34 SEWER-PROCESS	44 HOT OIL SUPPLY
TER-DEMINERALIZED	23 STEAM	29 NATURAL GAS	37 SEWER-NONCONTACT	45 HOT OIL RETURN
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TER-RIVER	35 CONDENSATE (LOW PRESS)	53 NITROGEN PADDING	41 PUMPOUT	49 VACUUM
Y DISCONNECT	36 ROOM AIR	54 EMERGENCY VENT	42 HOSE CONNECTION	50 PRESSURE TAP PLUGGED

NOTES

1. SPECIALTY CERAMIC
2. FUSES INTO LINE FR
3. PROVIDE LIQUID SEA
4. P-131 IS LOCATED I
5. ALARMS WHEN OIL IS
7. STEAM SPARGER IS S

ITEM NO.	P-131						E-102	E-103	E-192N/S			ITEM NO.
SERVICE	ANTI-FOAM PUMP						METHANOL SUBCOOLER	METHANOL STRIPPER CONDENSER	COOLER			SERVICE
SH. DES. PSIG/ °F	---						75/113	100/212				SIZE DIA s

Piping Designations

- Line Codes
- Spec breaks

Line Codes

- Size
- Service
- Mat'l of Constr or Piping Spec
- Insulation amount and Spec

Pipe size

“Nominal diameter”

1”, 2 1/2”, 4” etc.

Pipe Service

Coded to a designation shown on P&IDs

Examples: Methanol- Me

Reactor Product Stream- RxP

Material of Construction

- Generic

  Examples- *PVC*

  316L S/S

- Company or Project Specification

  Examples- *PP1*

  (a specification covering the materials and joining methods for PVC plastic pipe)

Insulation Code

- Thickness of insulation (inches)
- Type or Insulation Specification

  Example- F (fiberglass)

  - IN 9 (Project Specification for Calcium Silicate System)

- Tracing Code

  Examples- S (steam)

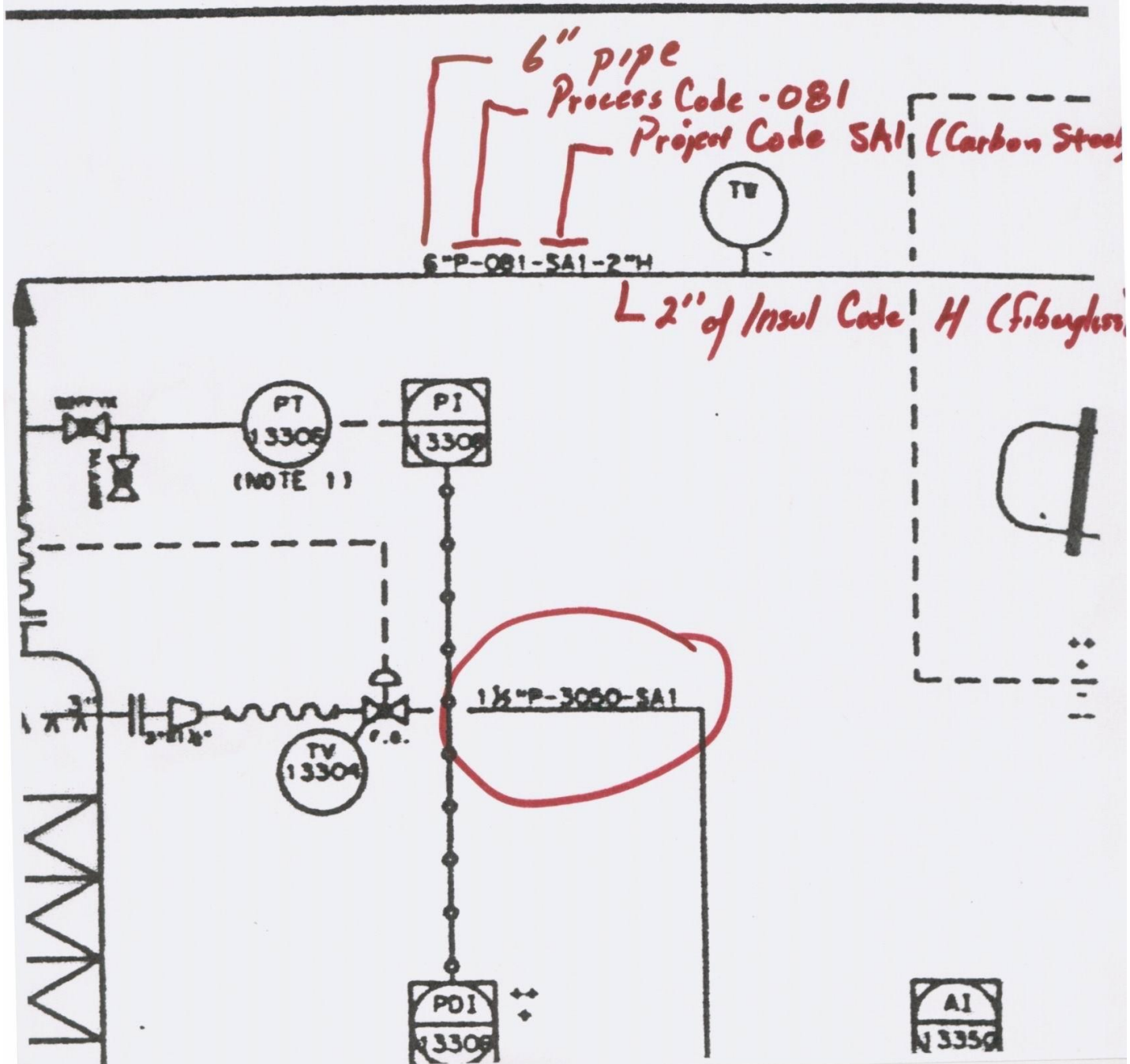
  E (electric)

Total Line Code

Example-

2” dia., Type 304 s/s pipe in acetic acid reactor discharge service, insulated with 1” of fiberglass insulation

2”AARX-304S/S-1”F


6" pipe
Process Code - 081
Project Code SA1 (Carbon Steel
TW
6"P-081-SA1-2"H
L 2" of Insul Code H (Fiberglass
PT
13306
(NOTE 1)
PI
13306
1½"P-3060-SA1
TV
13304
PDI
13306
AI
N3350

Spec Breaks

- A Line /Code changes every time *ANY ELEMENT* in the code changes

IE 3”AARX-304L S/S-1”F --> 3”AARX-304L S/S

at the point where the fluid has cooled enough to eliminate the insulation.

Spec Breaks are shown as

3”AARX-304L S/S-1”F 3”AARX-304L S/S

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Notes on P&IDs

- Normally read LEFT to RIGHT
  TOP to BOTTOM
- The Stream No.s, Ts, Ps and Flows from the PFD do NOT appear on a P& ID
- Equipment numbers are the same as on the corresponding PFD

THANK YOU

Qs ?