ME444 ENGINEERING PIPING SYSTEM DESIGN

CHAPTER 3 : PIPE DRAWING AND FLOW THEORY

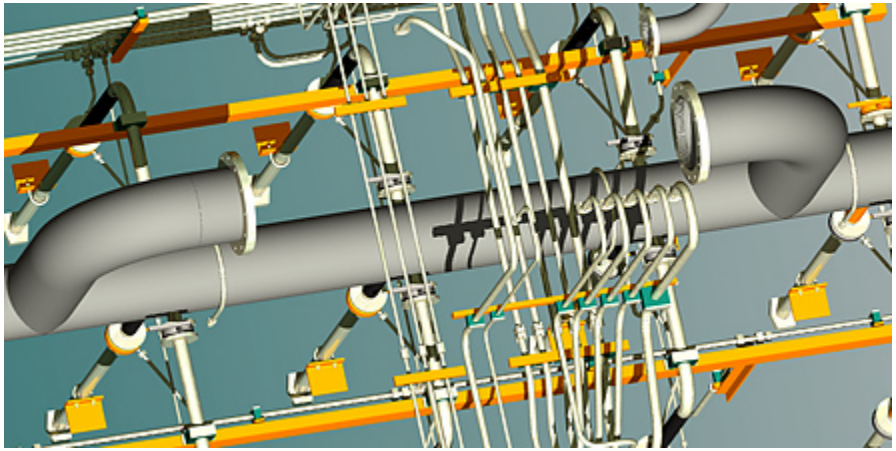
LAST SESSION

1. PIPES
2. VALVES
3. ACCESSORIES
4. PUMPS

CONTENTS

1. PIPE DRAWING
2. COST ESTIMATION

1. PIPING DRAWING



DRAWING IS A UNIVERSAL LANGUAGE

TYPES OF PIPING DRAWINGS

FLOOR PLAN
- SINGLE LINE
- DOUBLE LINE

SCHEMATIC or RISER
- FLAT
- ISOMETRIC

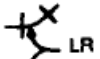
DETAIL DRAWING
- 2D
- 3D

DESIGN DRAWINGS
- Drawn by designers
- Used for contract bidding
- May be revised during construction

SHOP DRAWINGS
- Drawn by contractors
- More detail
- Solve on-site problem
- Ready for installation
- Used for contract bidding

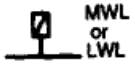
AS-BUILT DRAWINGS
- Drawn by contractors after installation complete
- Represent installed system
- Owners keep these drawing for reference

SYMBOLS - FITTINGS

Pipe fittings			
Symbol	Description	Symbol	Description
	Cross		Tee
	Cross (branch up)		Tee (branch up)
	45° elbow		Tee (branch down)
	45° elbow (up)		Side outlet tee (up)
	45° elbow (down)		Reducer
	Lateral		Eccentric reducer (Elevation)
	90° elbow		Union, screwed
	90° elbow (up)		Sleeve coupling
	90° elbow (down)		Sleeve coupling (harnessed)
	45° elbow (long radius)		Meter (identify type)
	90° elbow (long radius)		Venturi meter

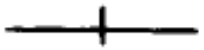
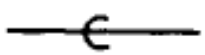
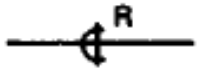
SYMBOLS – FITTINGS (2)

Pipe fittings

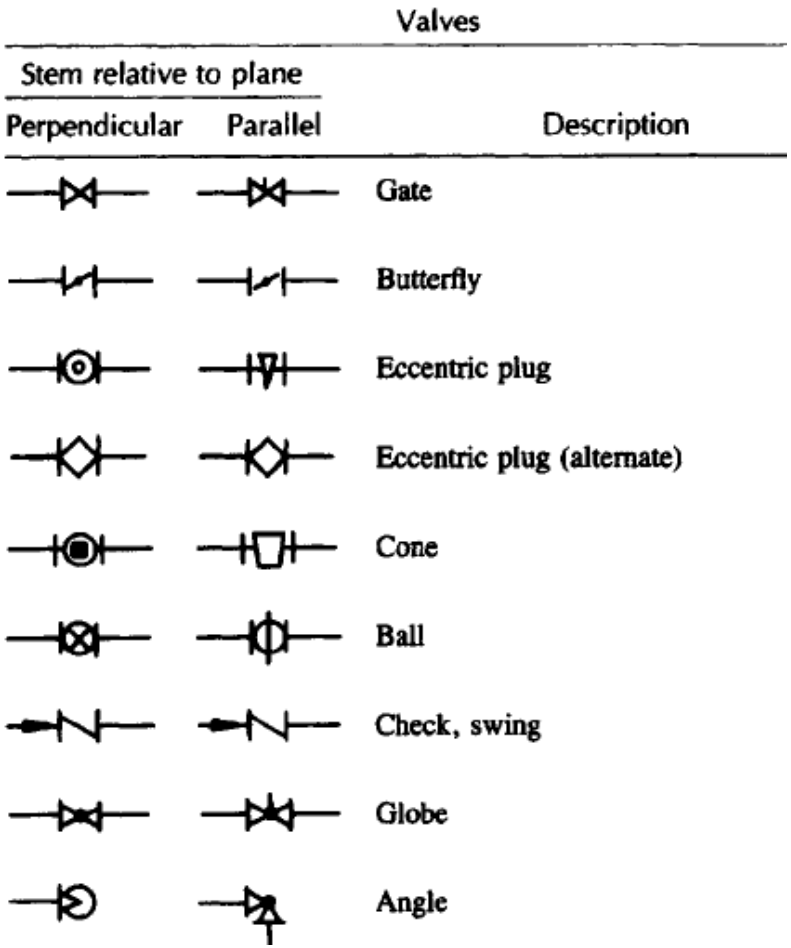
Symbol	Description	Symbol	Description
	45° elbow (long radius)		Meter (identify type)
	90° elbow (long radius)		Venturi meter
	Base elbow		Expansion joint, metal bellows
	Side outlet elbow (up)		Expansion joint, rubber bellows
	Side outlet elbow (down)		Strainer
	Duplex strainer		Thermostat
	Flame trap		Pressure gauge
	Lube oil filter		Water level alarm
	Scale trape		
	Vent		Thermometer

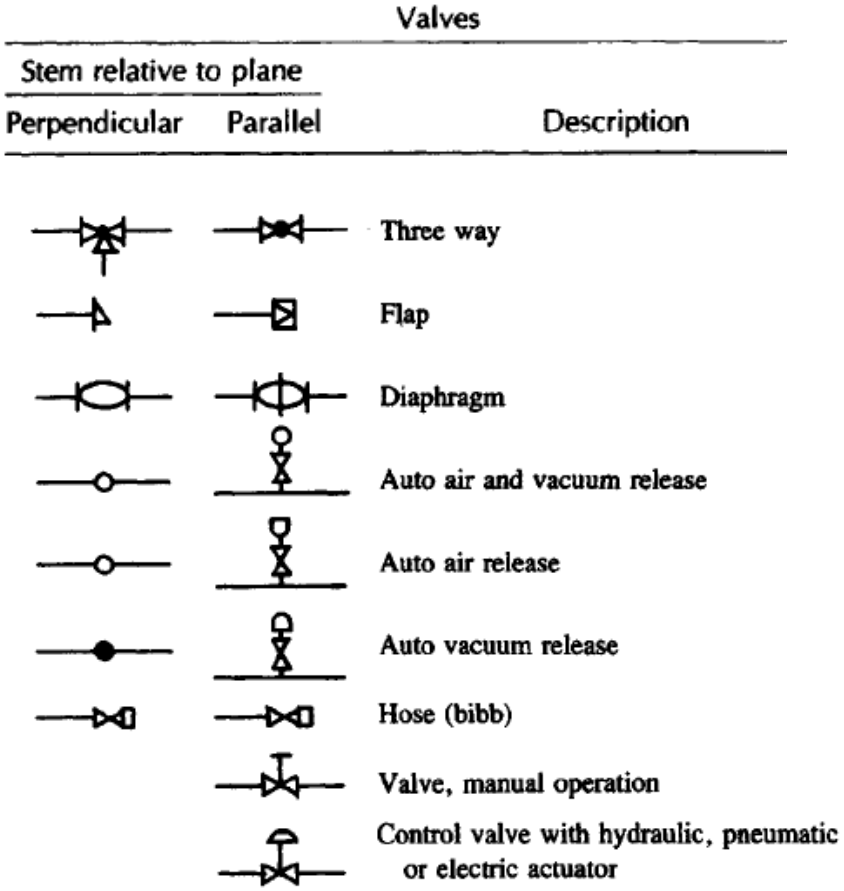
SYMBOLS - JOINTS

Pipe joints

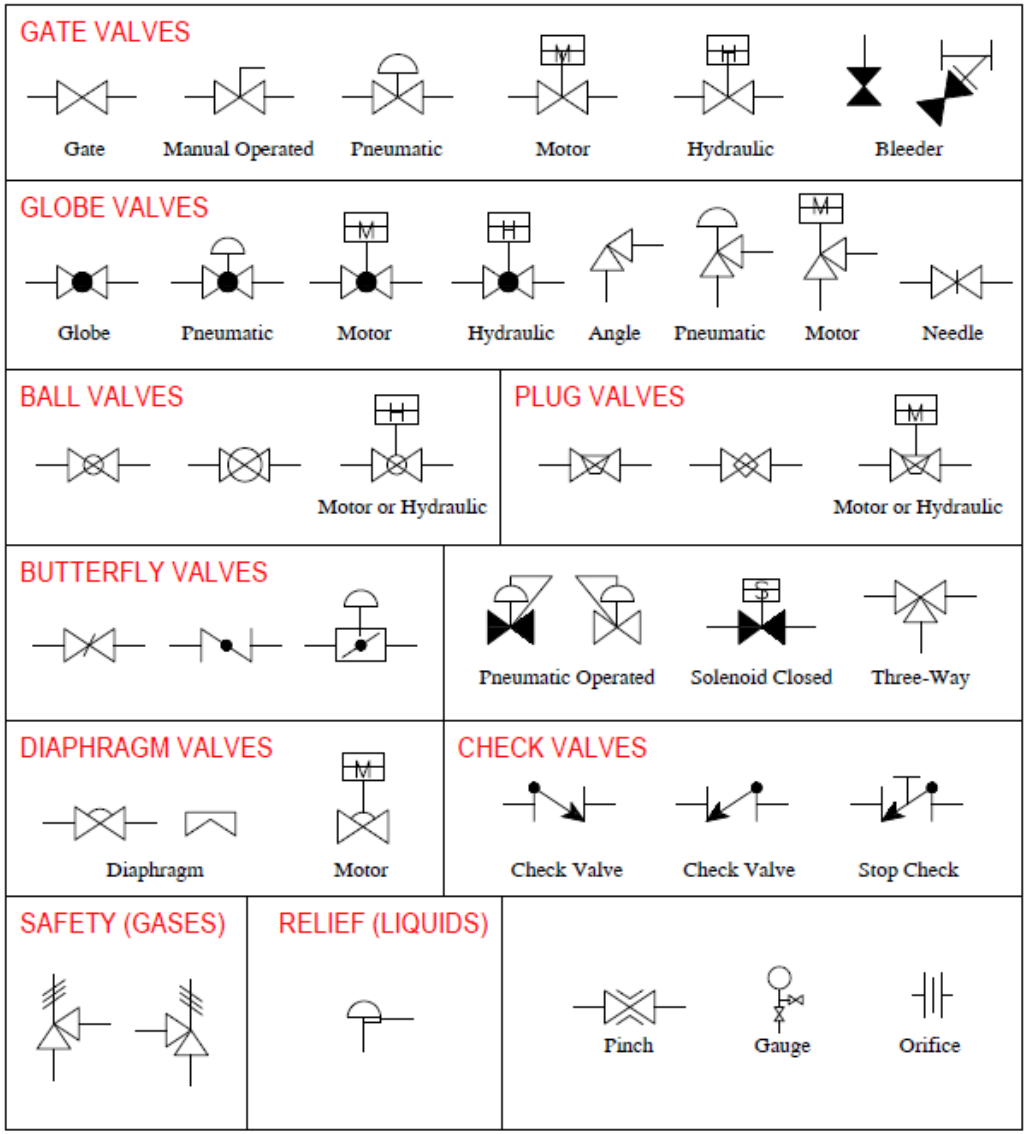
Symbol	Description
	Flange
	Bell and spigot
	Mechanical joint
	Mechanical joint, restrained
	Bell and ball

SYMBOLS - VALVES





SYMBOLS - VALVES



SYMBOLS - FIXTURES

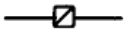
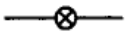
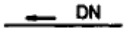
Fixture symbols			
Symbol	Description	Symbol	Description
FD	Floor drain	WH	Water heater
AD	Area drain	L	Lavatory
RD	Roof drain	S	Sink
A	Compressed air outlet	SH	Shower stall
G	Gas outlet	U	Urinal
VAC	Vacuum outlet	WC	Water closet
HB	Hose bibb	WC	Water closet, wall hung
DF	Drinking fountain	EWC	Electric water cooler

SYMBOLS – PIPES (1)

Piping symbols

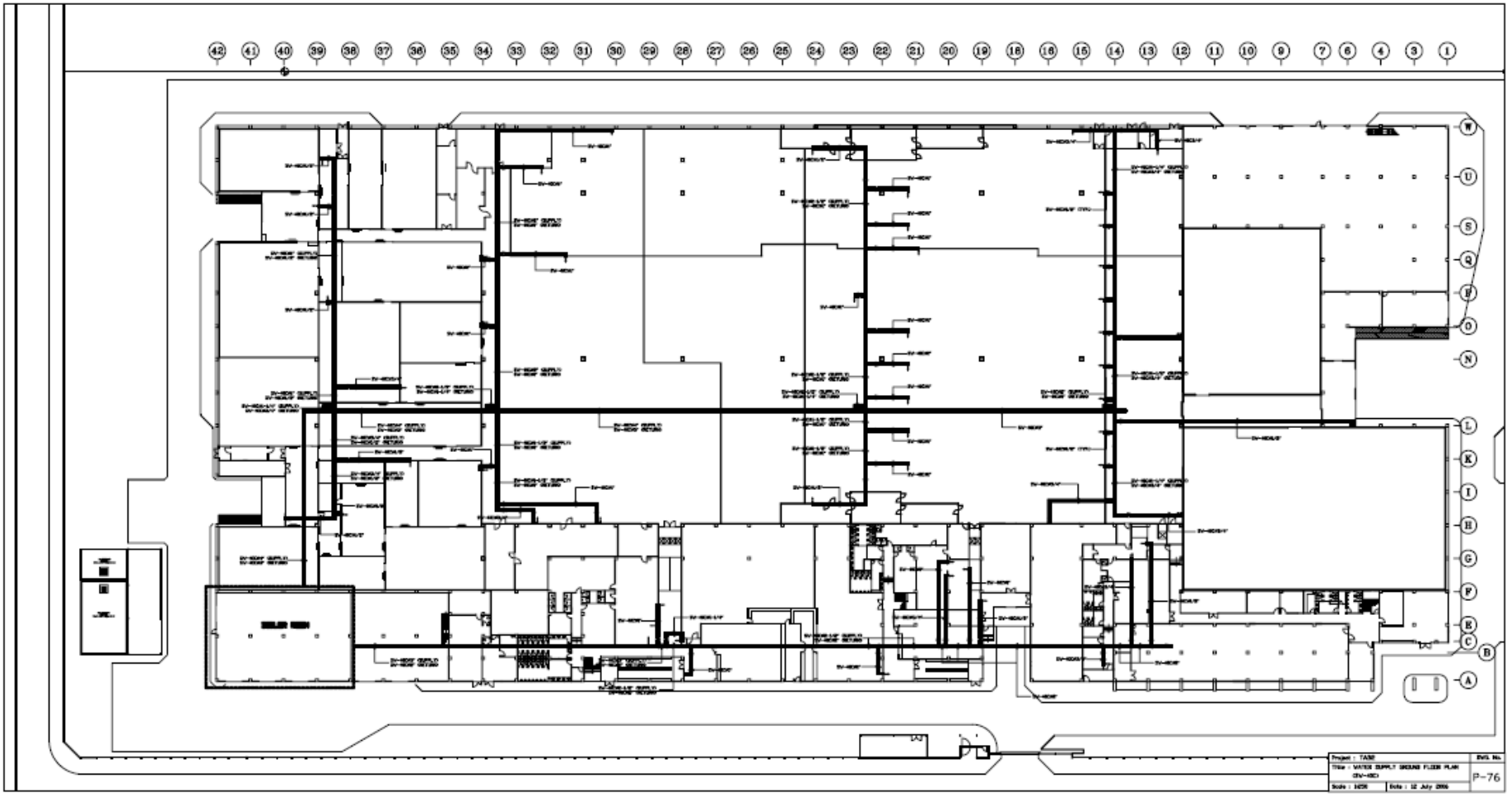
Symbol	Description	Symbol	Description
ST	Storm	F	Fire protection
S	Soil	SP	Fire sprinkler
W	Waste	Plan El: DT DT	Drum trap
D	Drain		P-trap
V	Vent	RT RT	Running trap
AW	Acid waste		Backflow preventer
AV	Acid vent	CO	Cleanout (exposed pipe)
SW	Service water	CO	Cleanout (floor or grade)
CW	Cold water	HWS	Heating water supply
EW	Effluent water	HWR	Heating water return

SYMBOLS – PIPES (2)

Symbol	Description	Symbol	Description
LPS	Low-pressure steam		Three-way control valve * (P): pneumatic * (E): electric
LPC	Low-pressure condesate		
MPS	Medium-pressure steam		Control valve * (P): pneumatic * (E): electric
MPC	Medium-pressure condensate		
HPS	High-pressure steam		Pipe guide
HPC	High-pressure condensate		Pipe anchor
FOS	Fuel oil supply		Float and thermostatic trap
FOR	Fuel oil return		Thermostatic trap
BF	Boiler feed		Expansion joint
NG	Natural gas		Expansion joint (harnessed)
LPG	Liquefied petroleum gas		Pipe flow direction
RL	Refrigerant liquid		Pipe pitch down with respect to flow
RS	Refrigerant suction		Pipe pitch up with respect to flow
CPD	Condensate pump discharge		Pipe capped

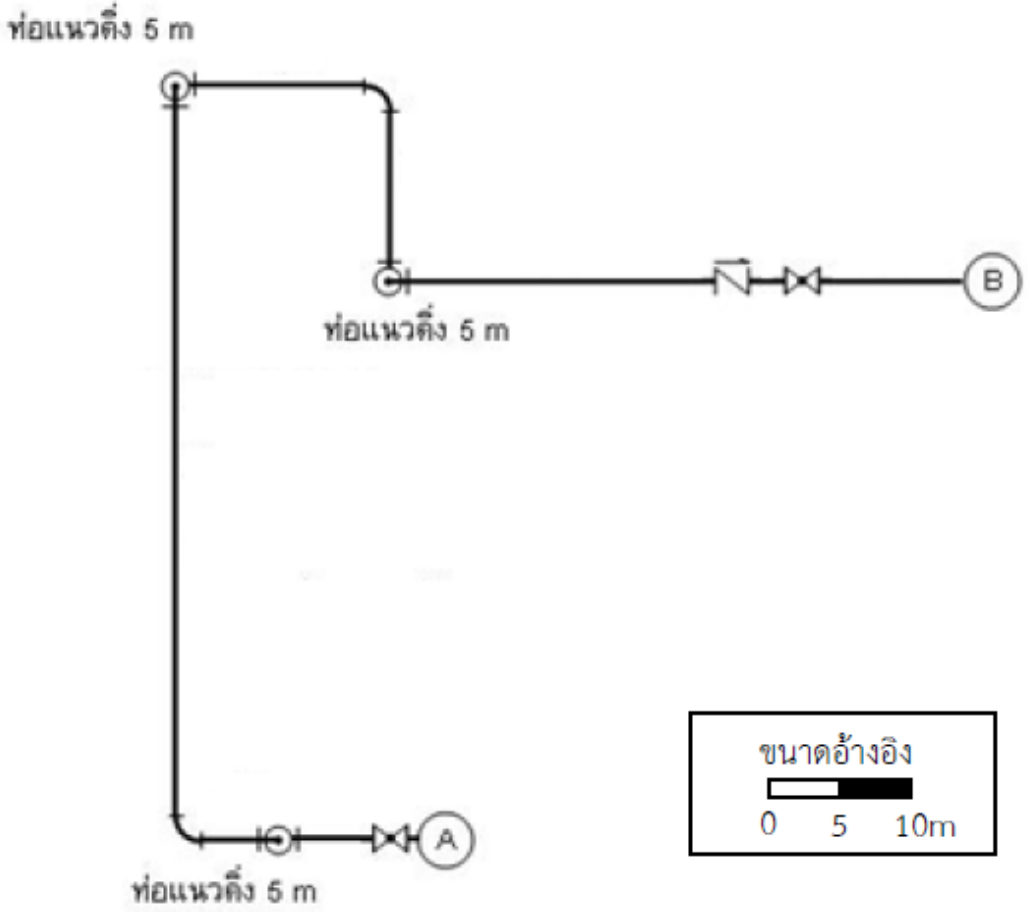
MORE IN PUMPING STATION DESIGN

PIPING DRAWING - FLOOR PLAN



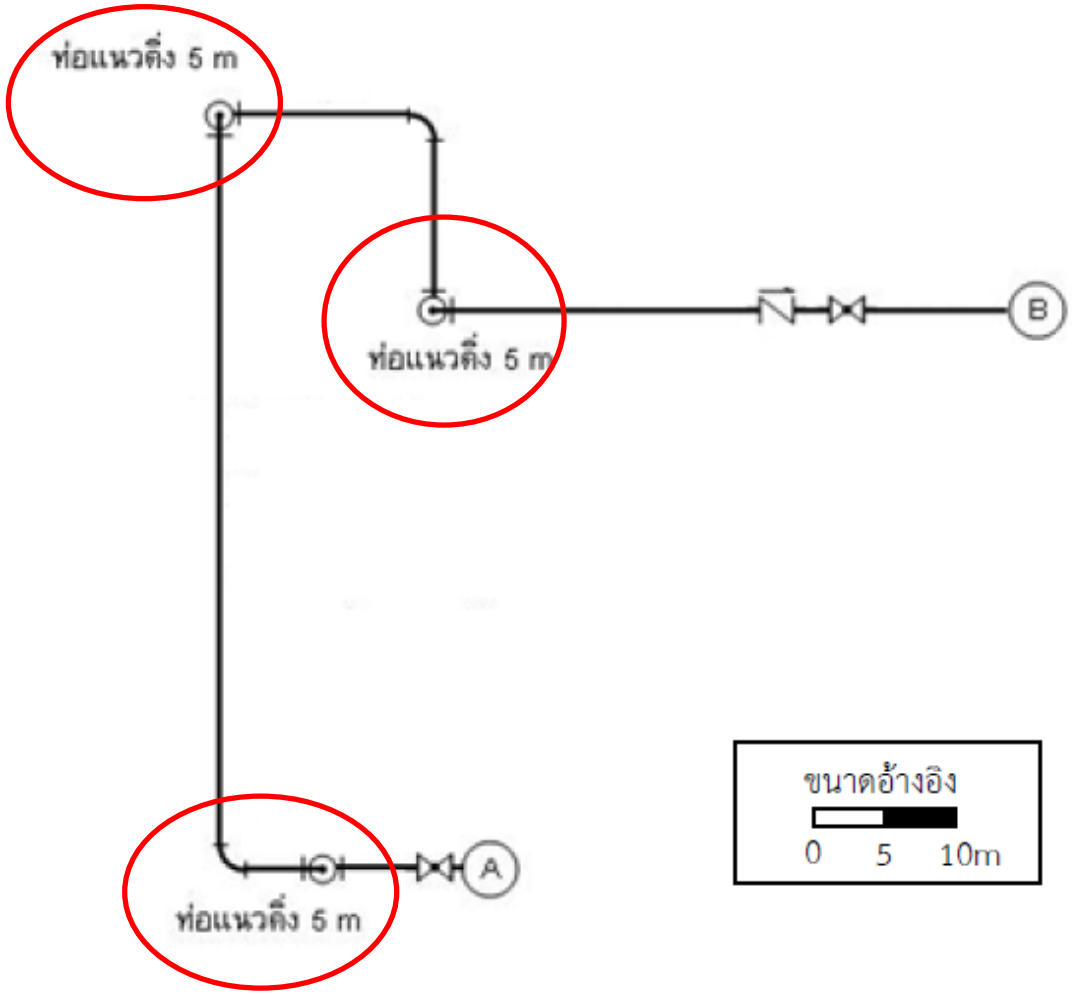
EXAMPLE 3.1 - ISOMETRIC

Sketch an isometric view of the following pipeline.

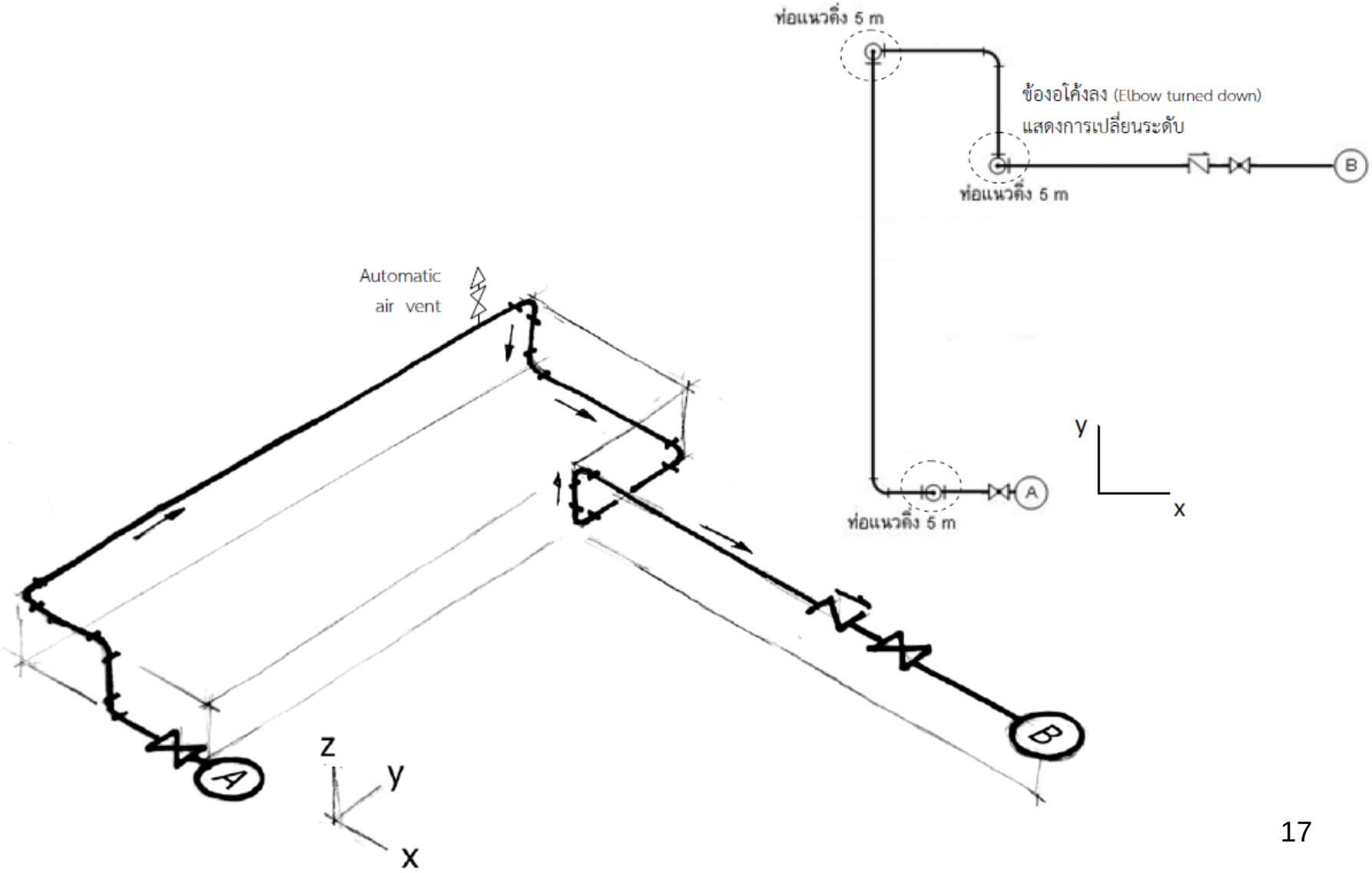


EXAMPLE 3.1 - ISOMETRIC

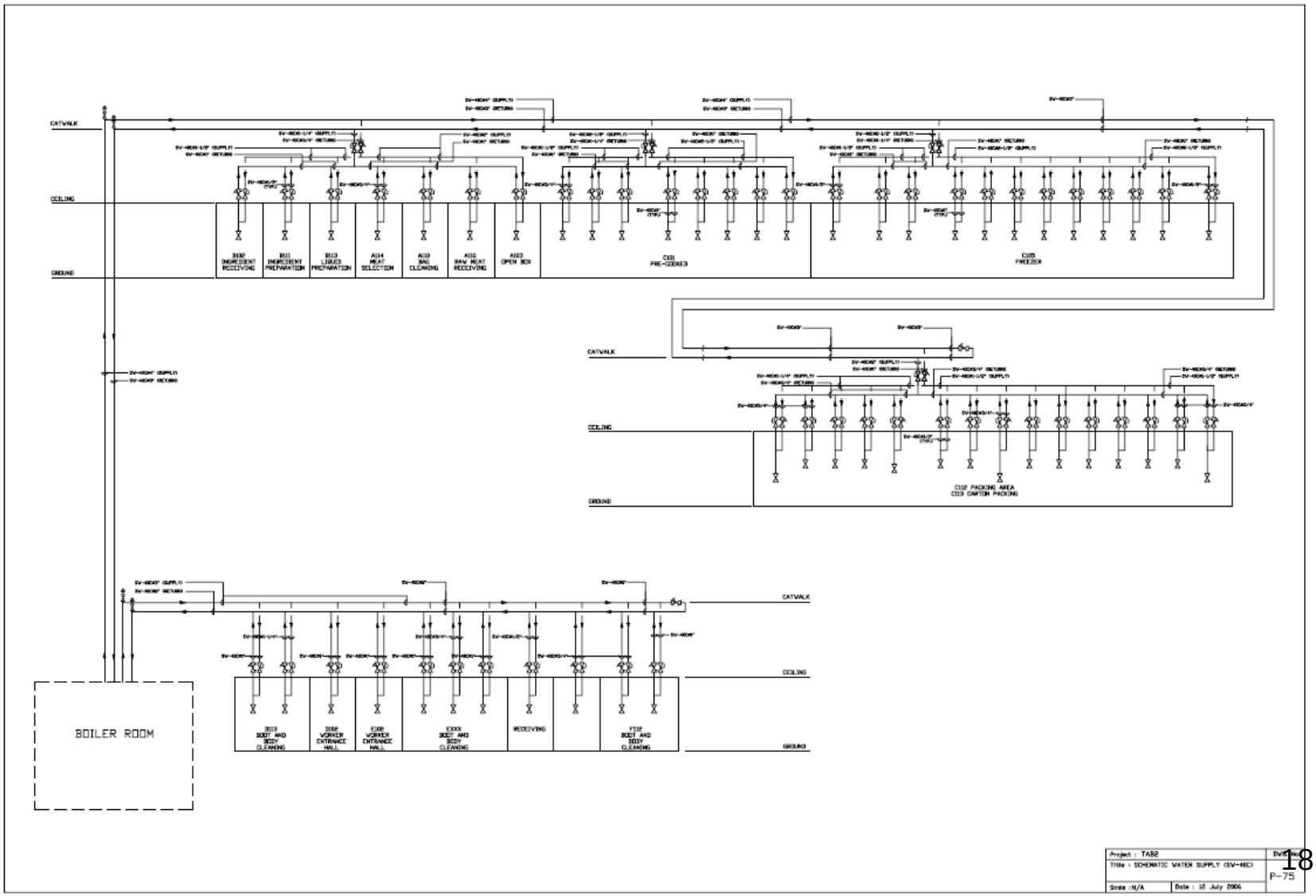
Note the level changes.



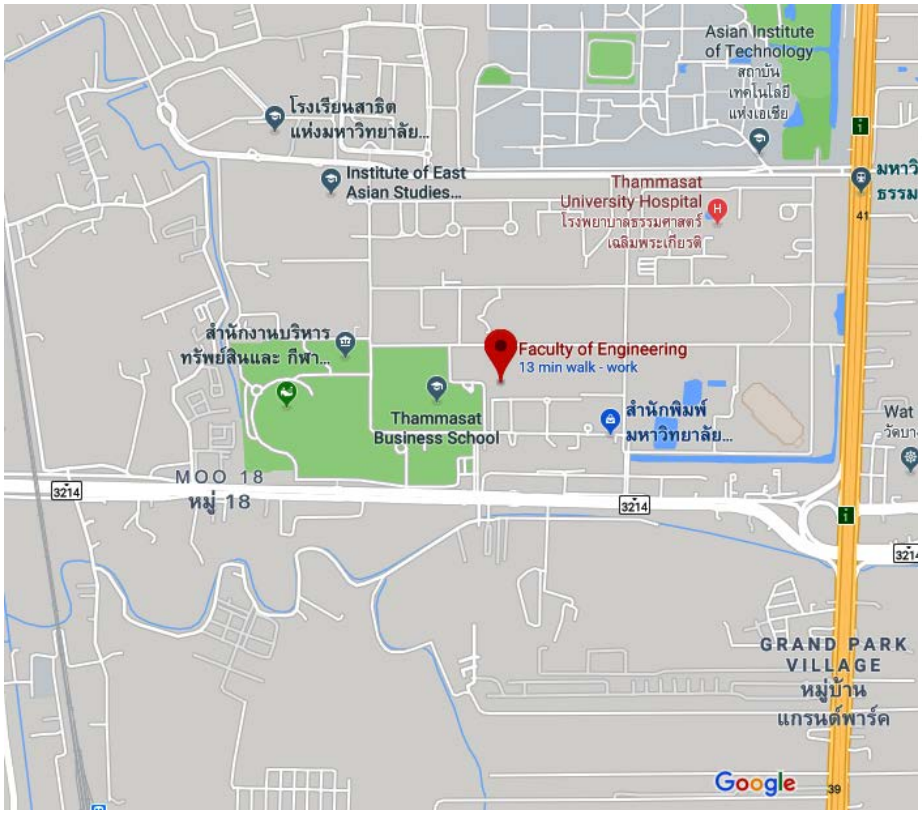
EXAMPLE 3.1 - ISOMETRIC



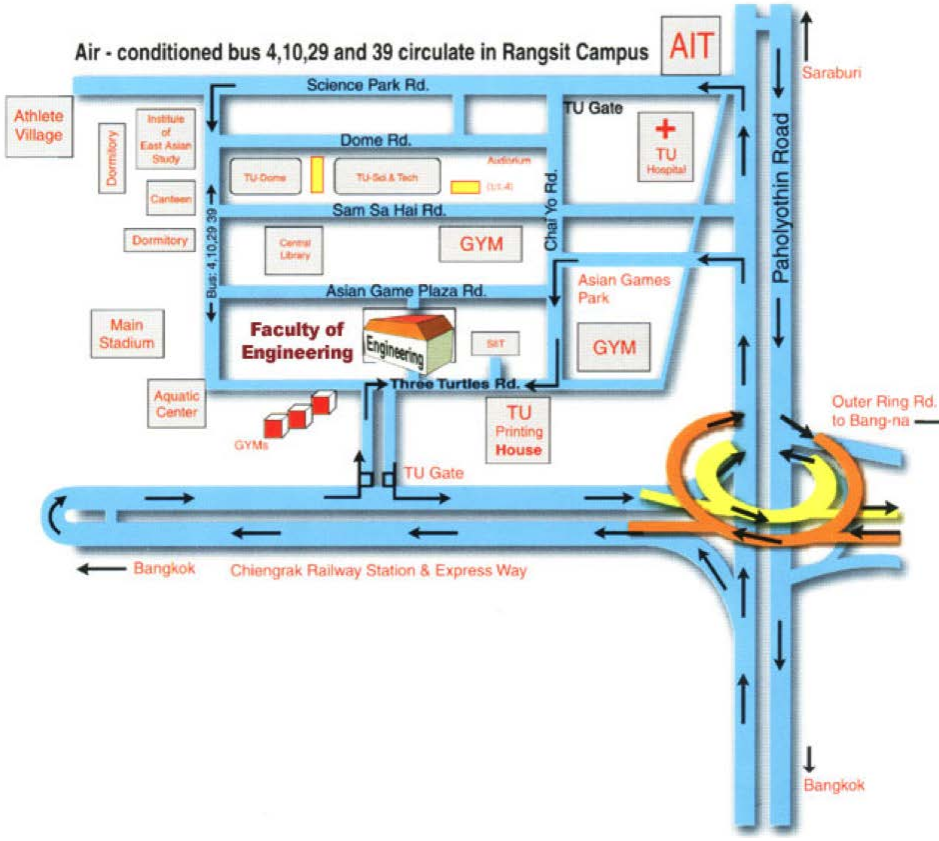
PIPING SYSTEM SCHEMATIC DIAGRAM (FLAT)



IDEA OF FLOOR PLAN VS SCHEMATIC DIAGRAM

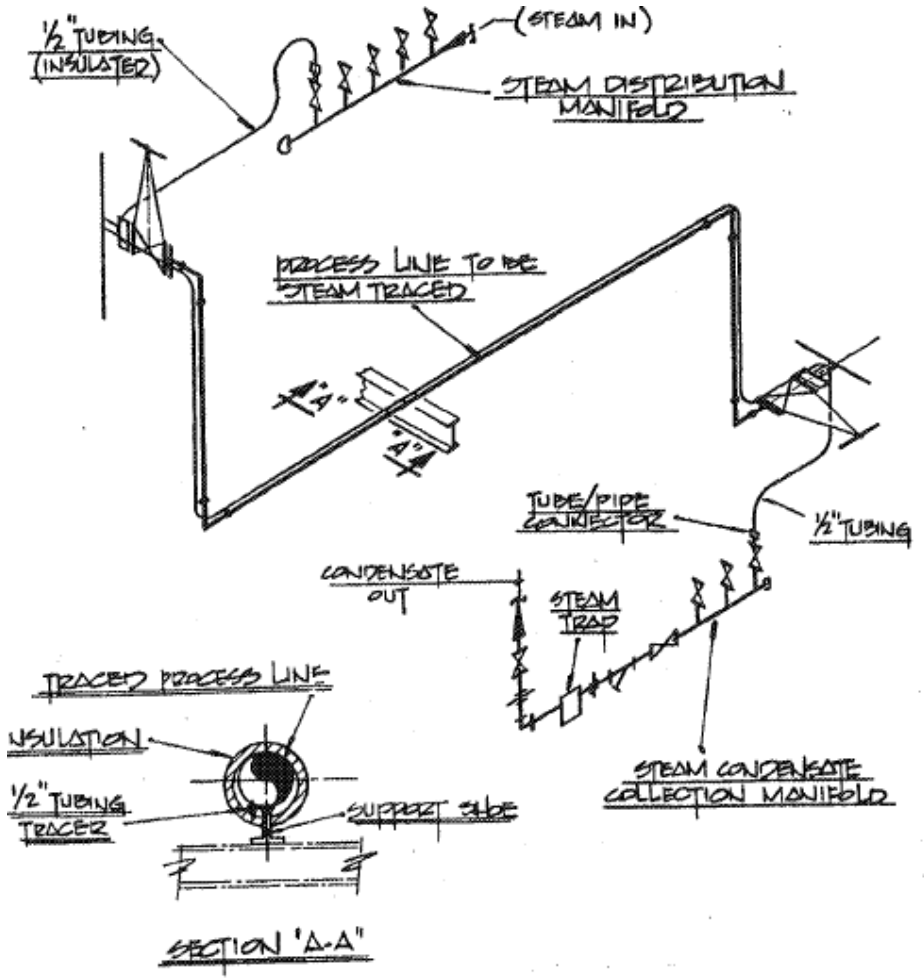


True scale, true detail

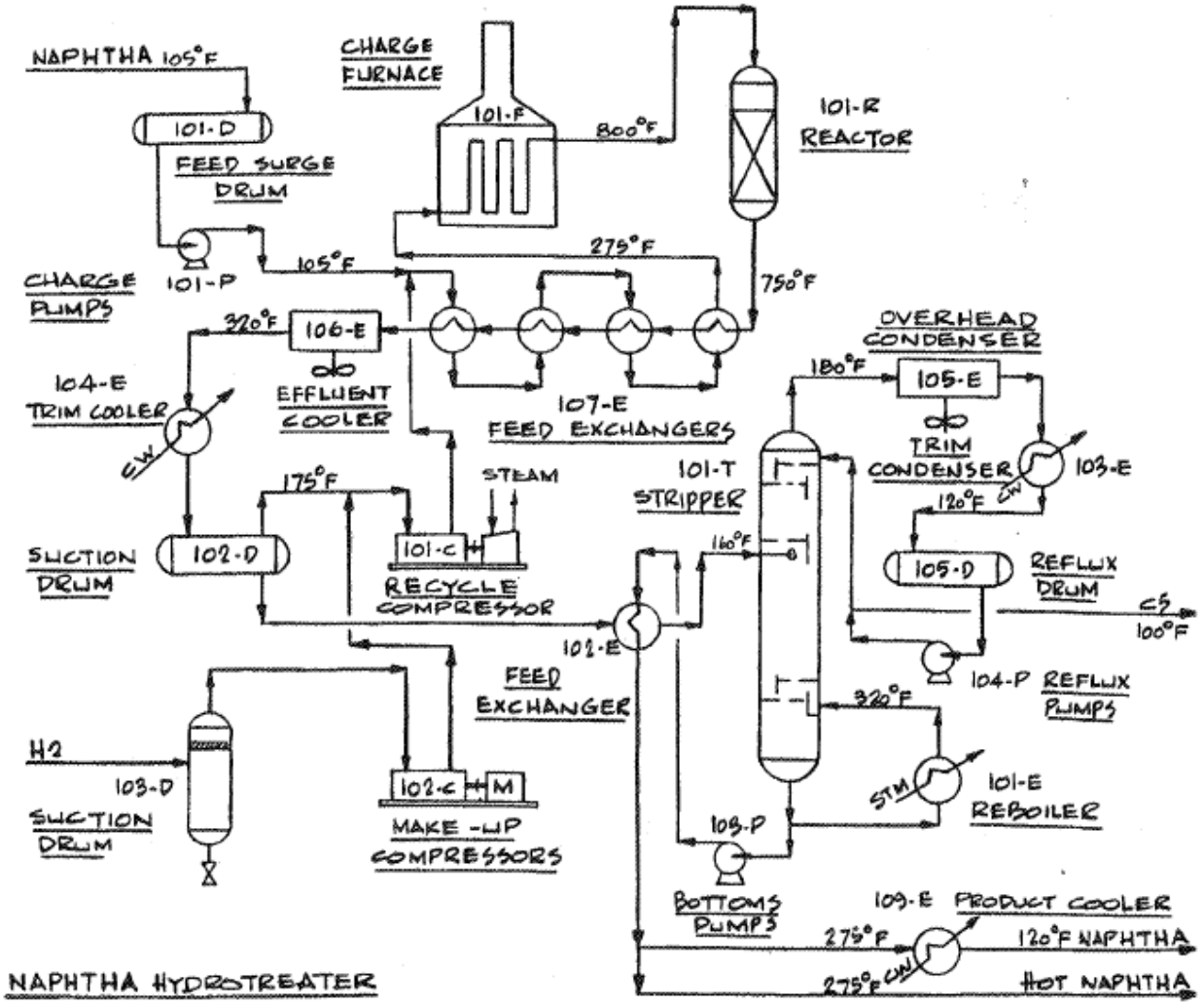


Simplified, easy to read

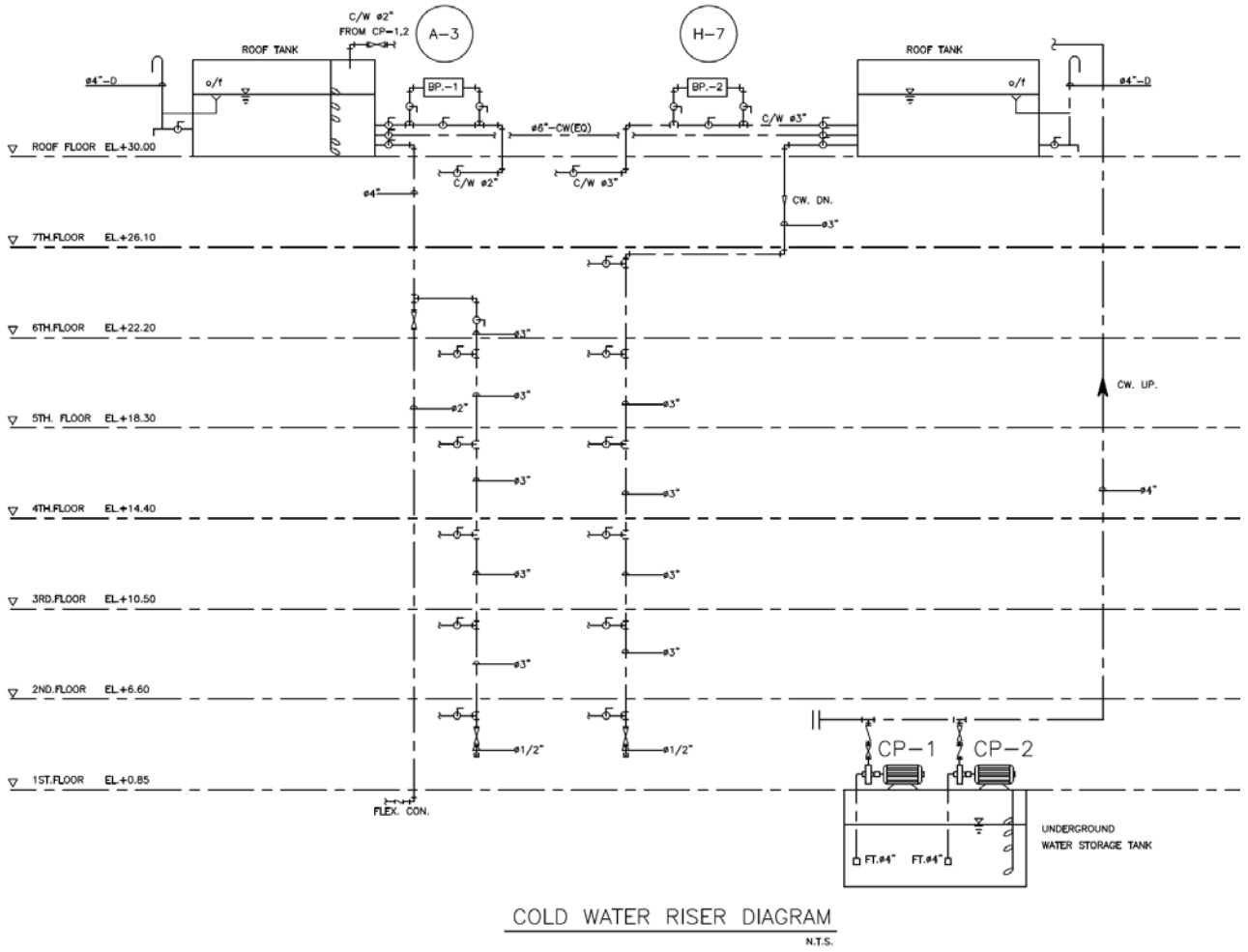
SCHEMATIC DIAGRAM (ISOMETRIC)



PROCESS SCHEMATIC DIAGRAM



RISER DIAGRAM



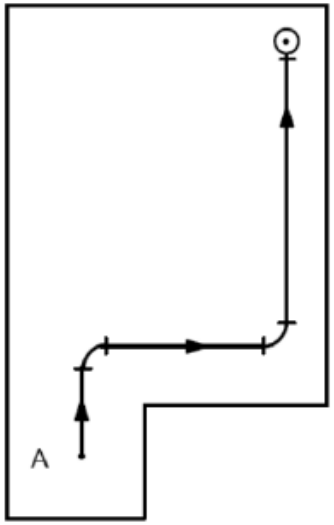
COLD WATER RISER DIAGRAM

N.T.S.

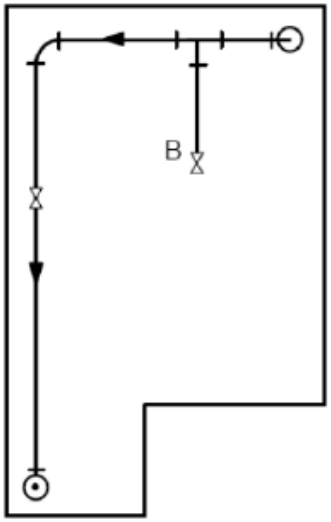
Schematic diagrams can also represent elevation, (or side view)
Used in tall building

EXAMPLE 2 – Schematic Diagram

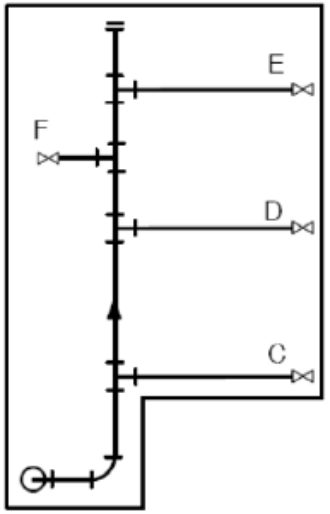
Sketch an isometric view and a schematic diagram of the following system



1ST FL. EL +0.00



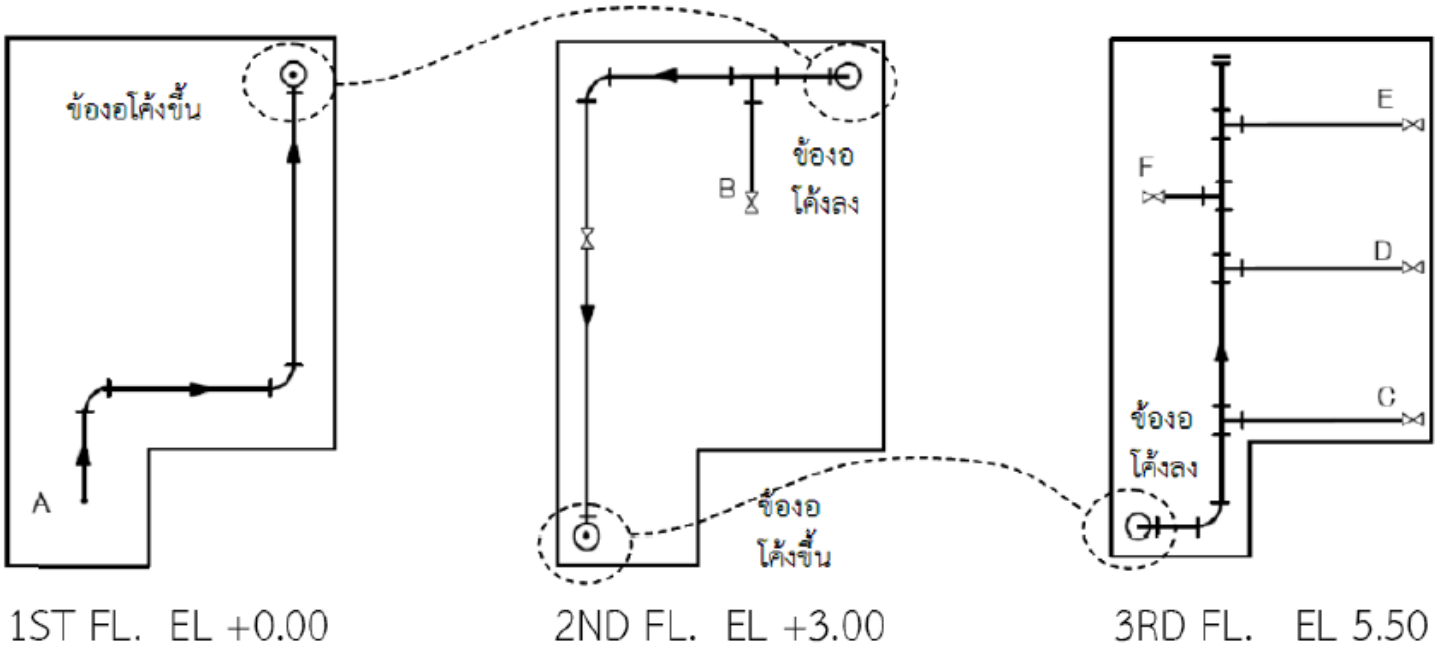
2ND FL. EL +3.00



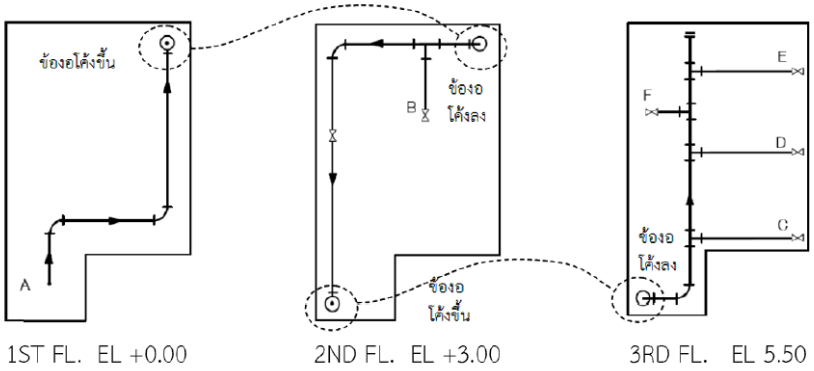
3RD FL. EL 5.50

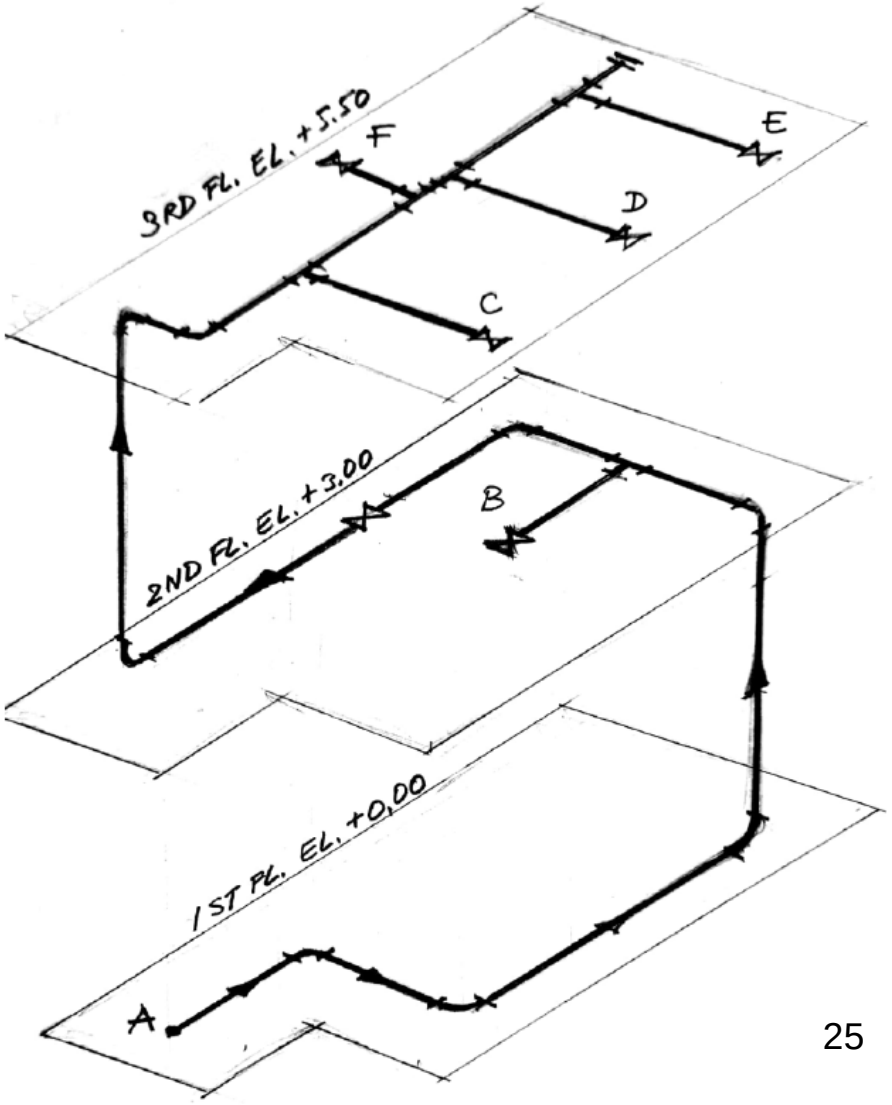
EXAMPLE 2 – Schematic Diagram

Note the connection points

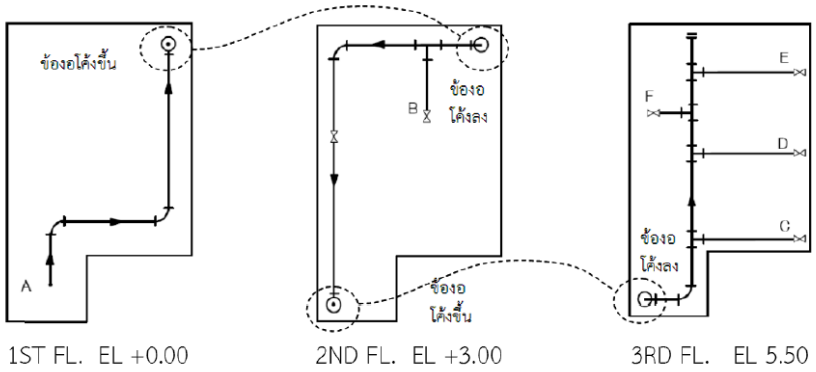


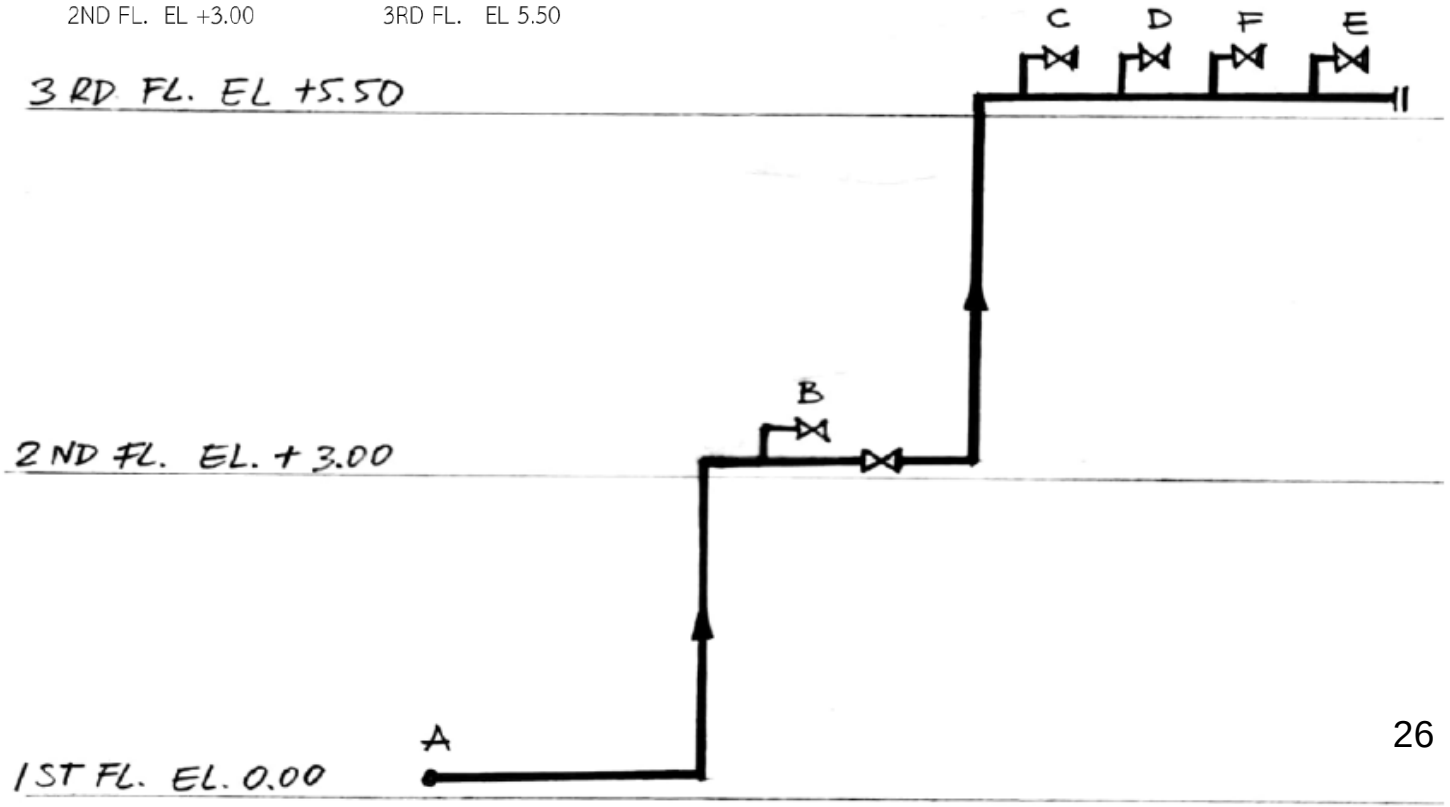
EXAMPLE 2 – Schematic Diagram



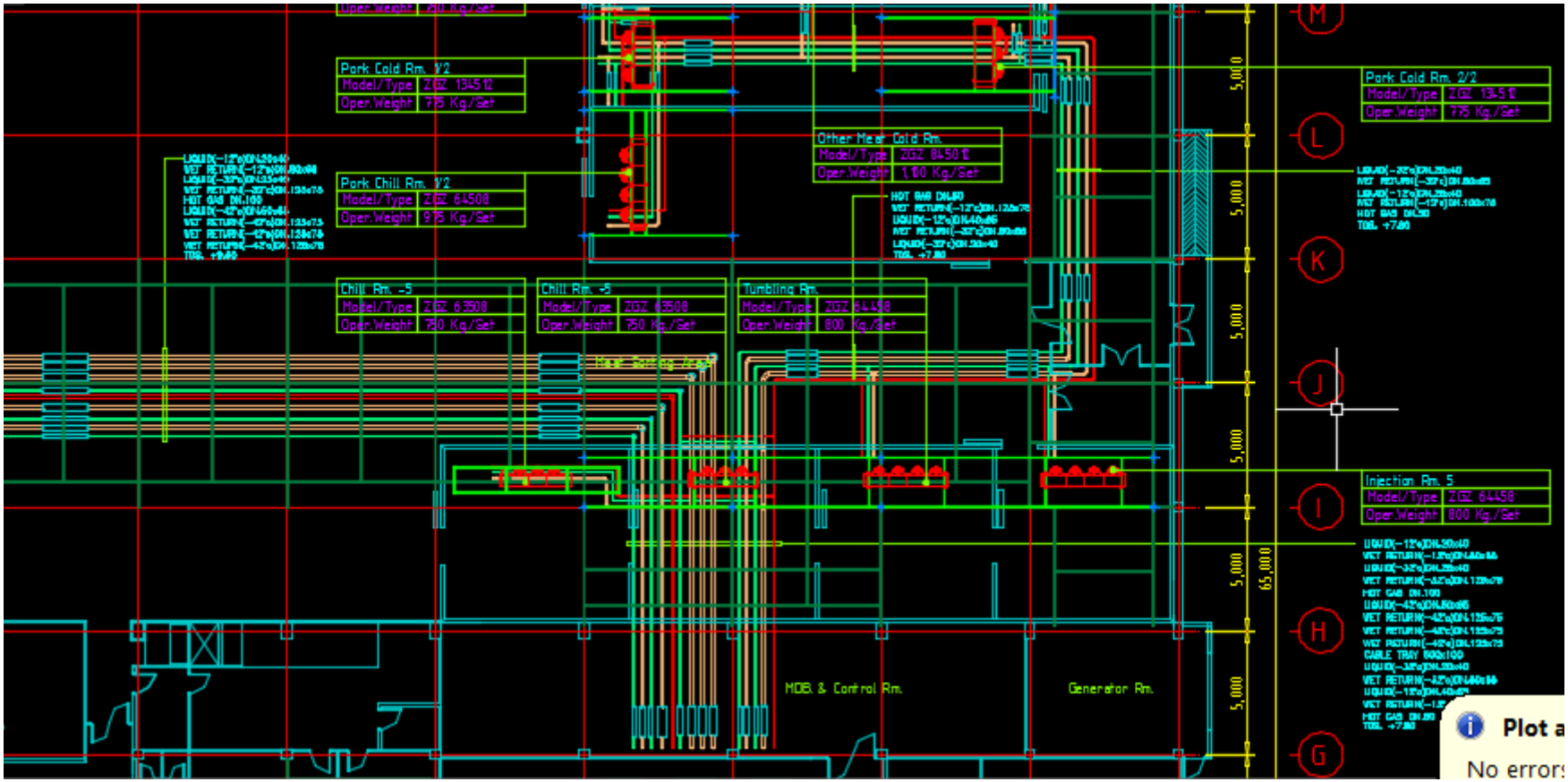


EXAMPLE 2 – Schematic Diagram



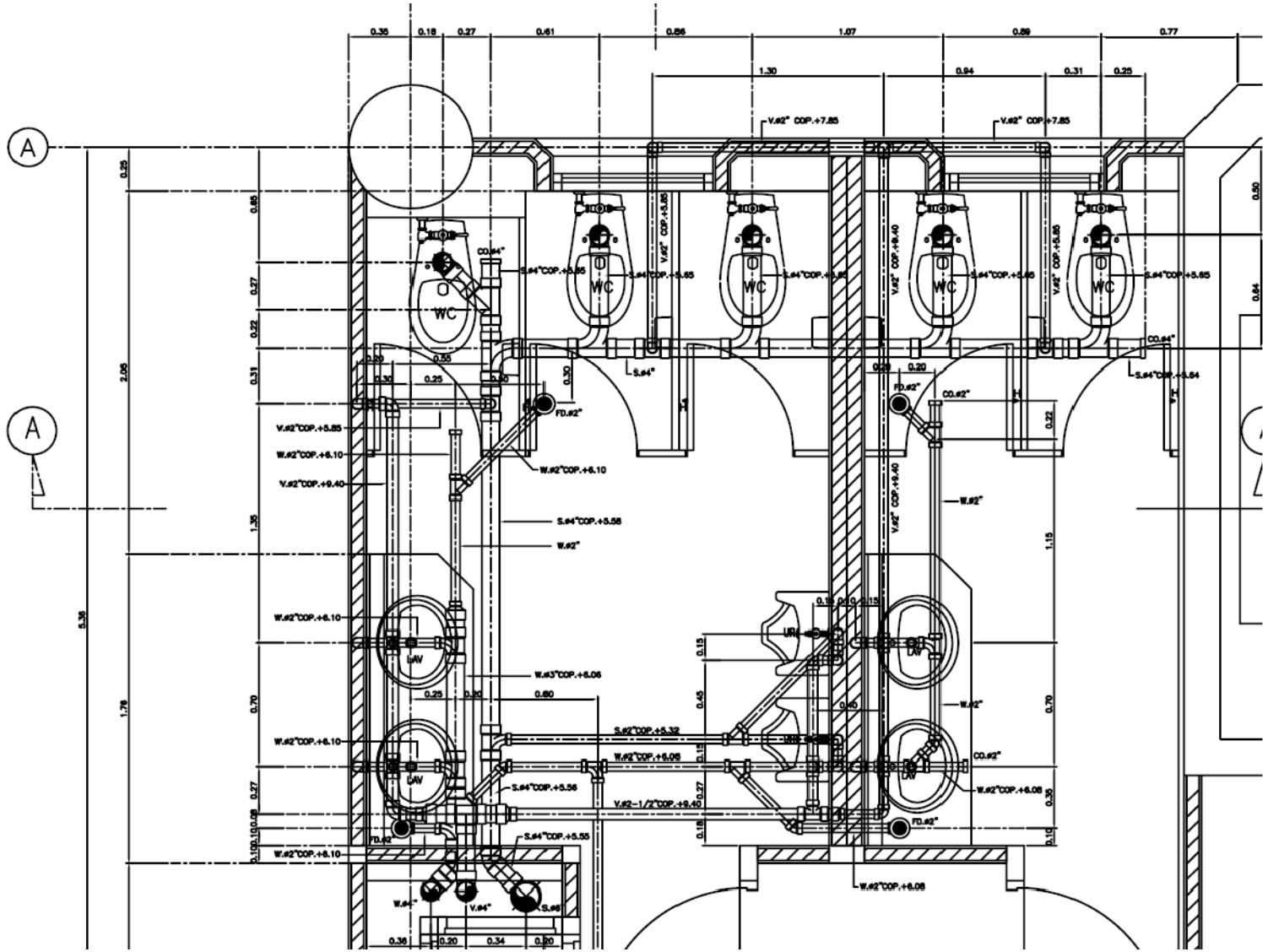


DOUBLE LINE PIPE DRAWING

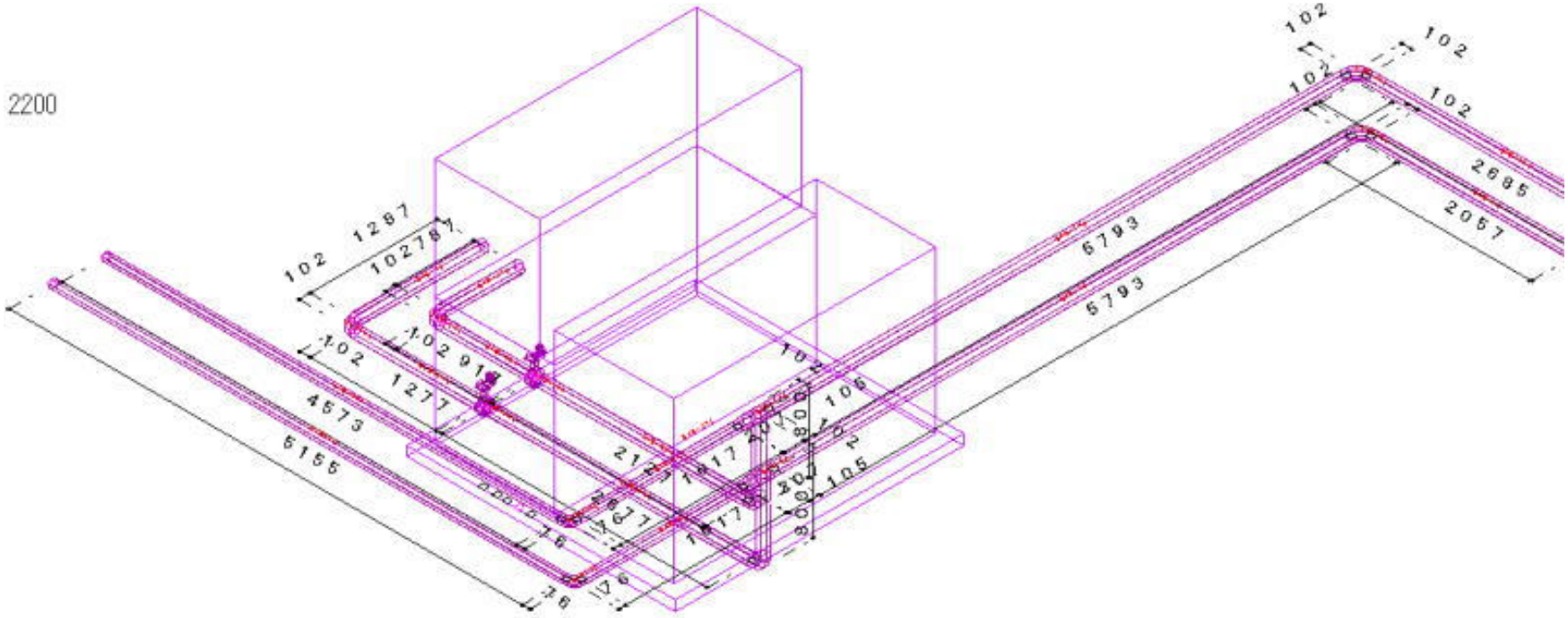


Represent pipe sizes. Usually found in Shop and As-built drawing

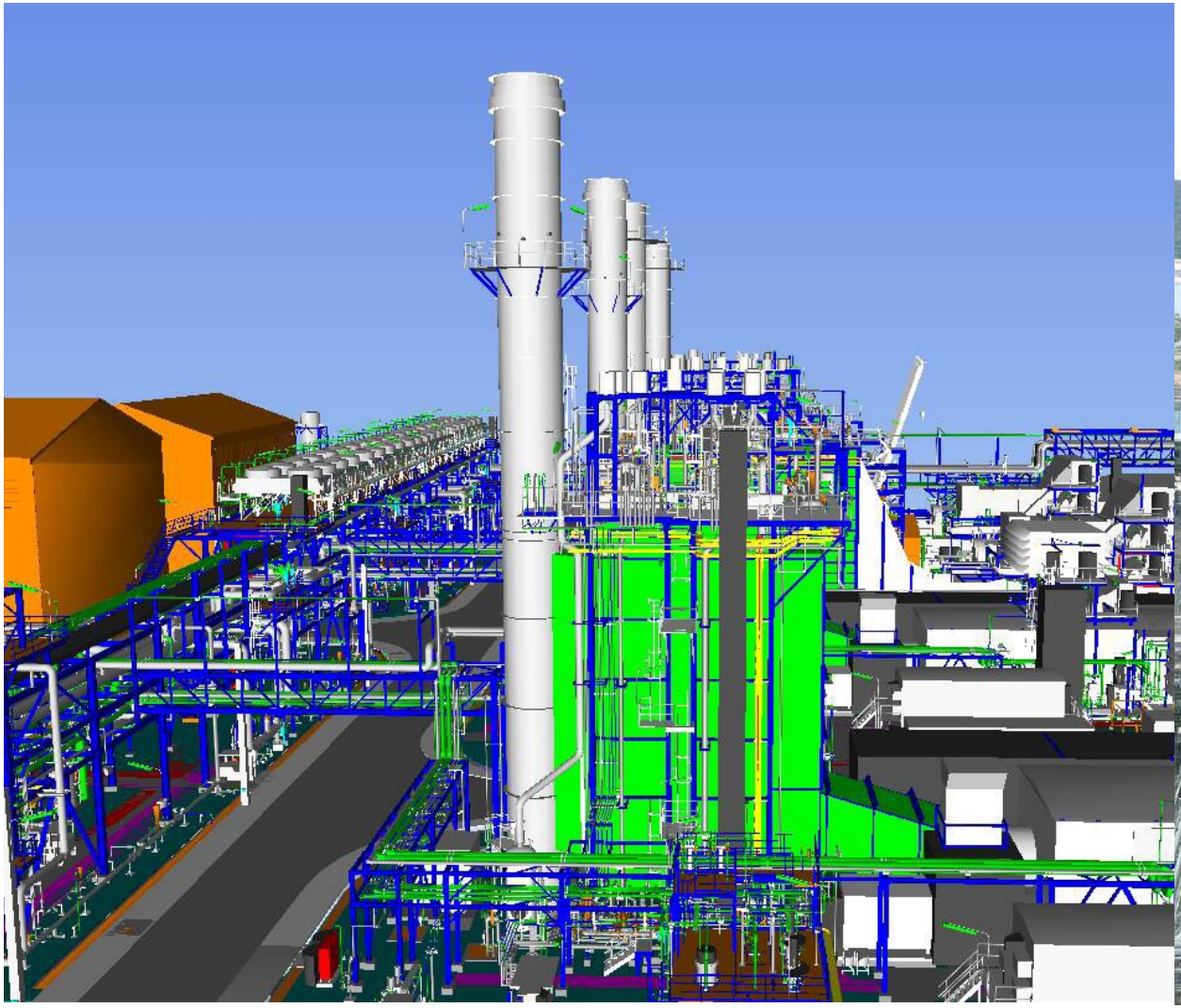
DOUBLE LINE PIPE DRAWING



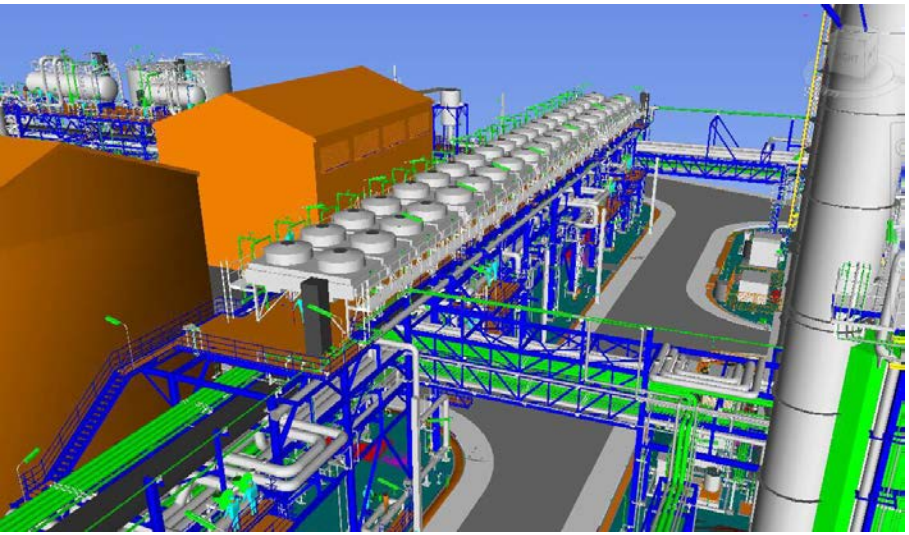
3D PIPE DRAWING

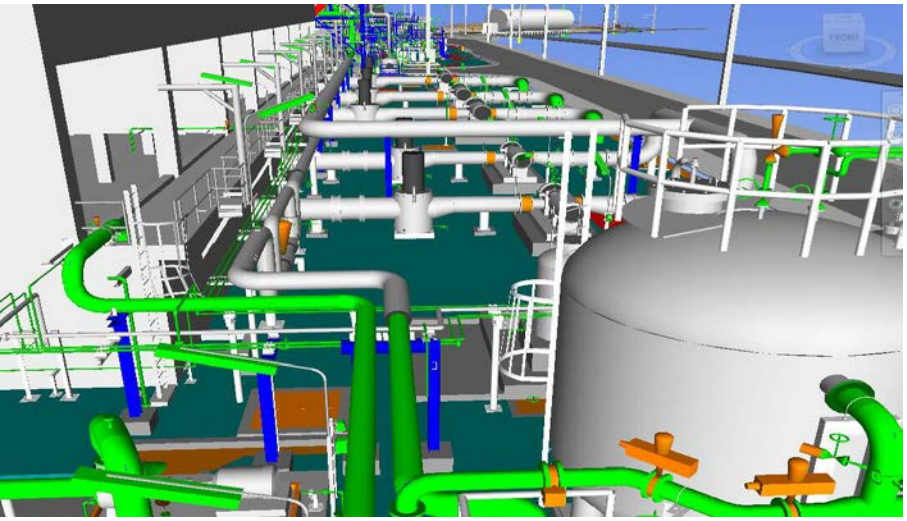


MODERN PIPE DESIGN SOFTWARE



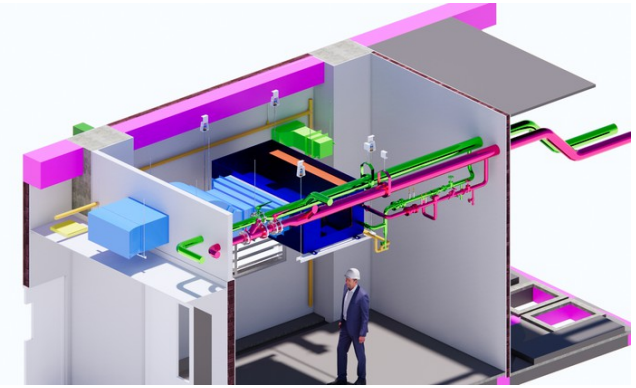
MODERN PIPE DESIGN SOFTWARE

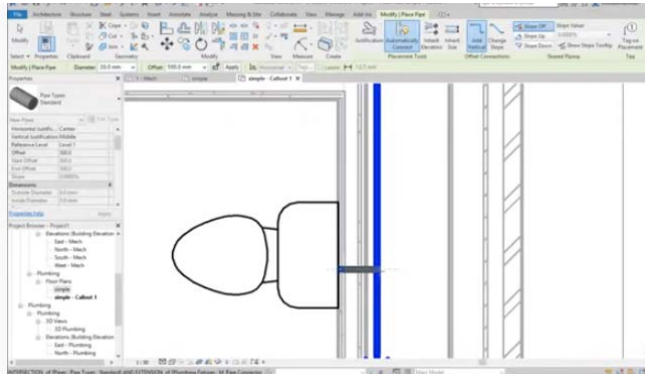


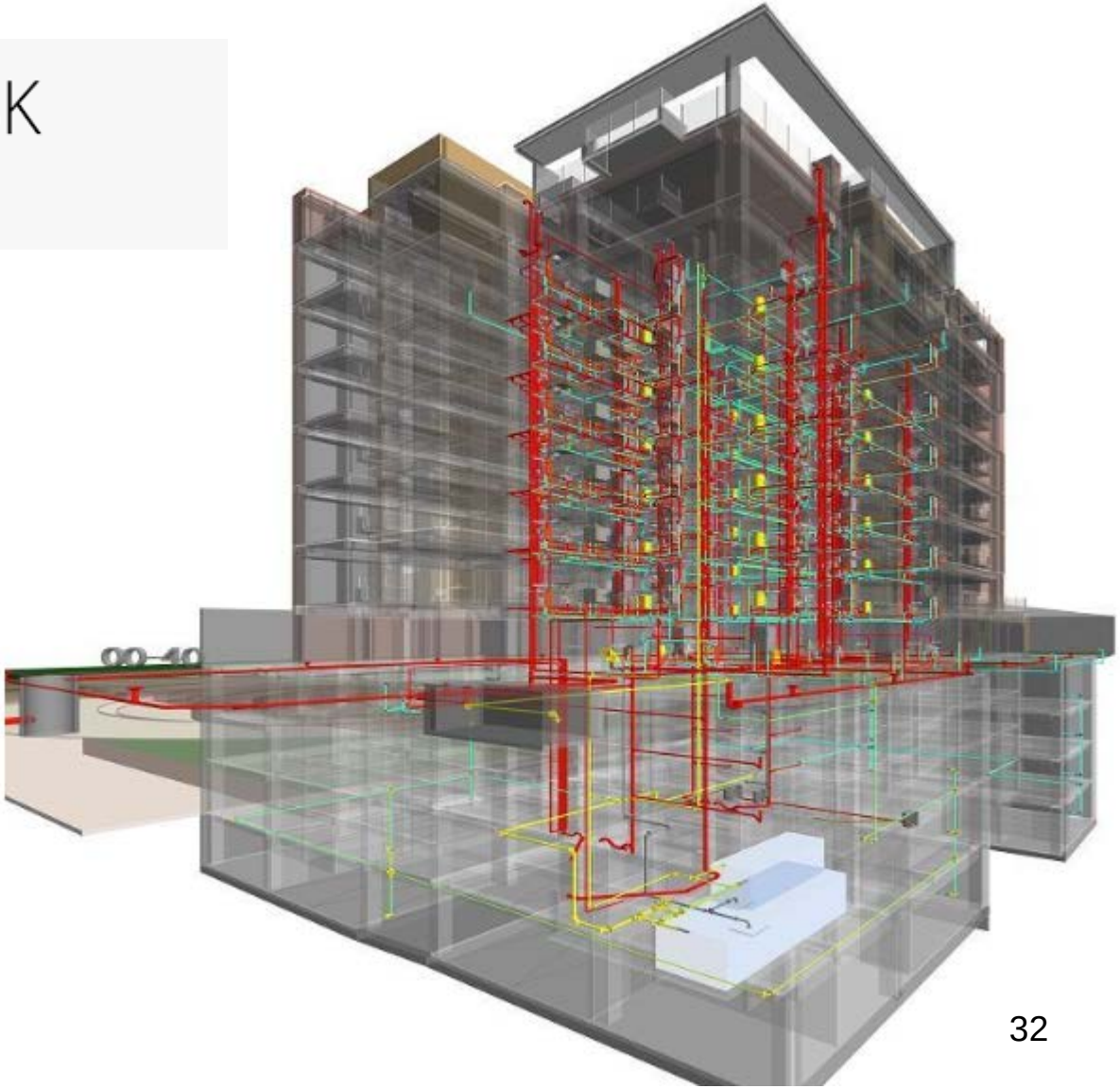


BIM (BUILDING INFORMATION MODELING)

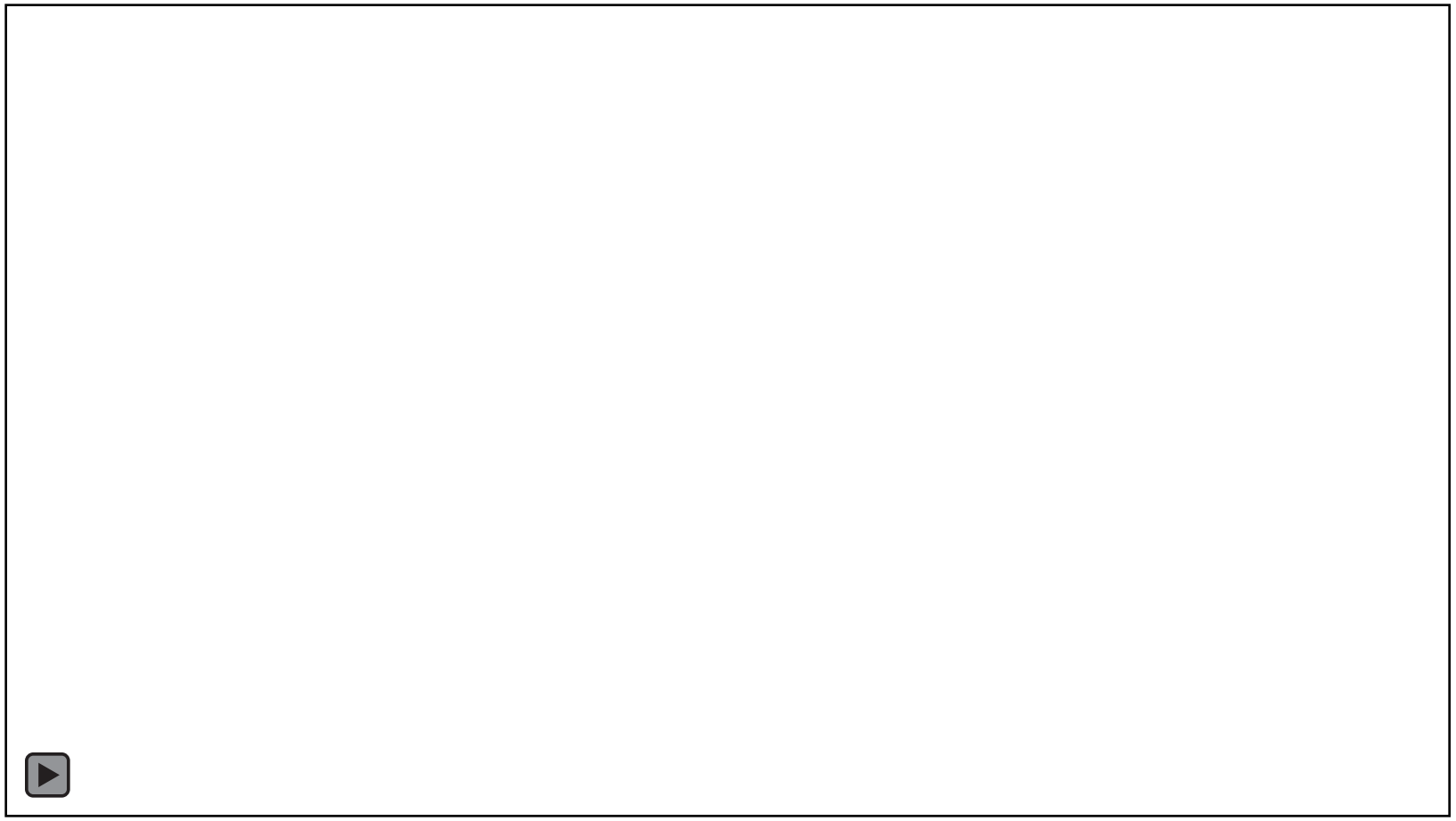
AUTODESK REVIT





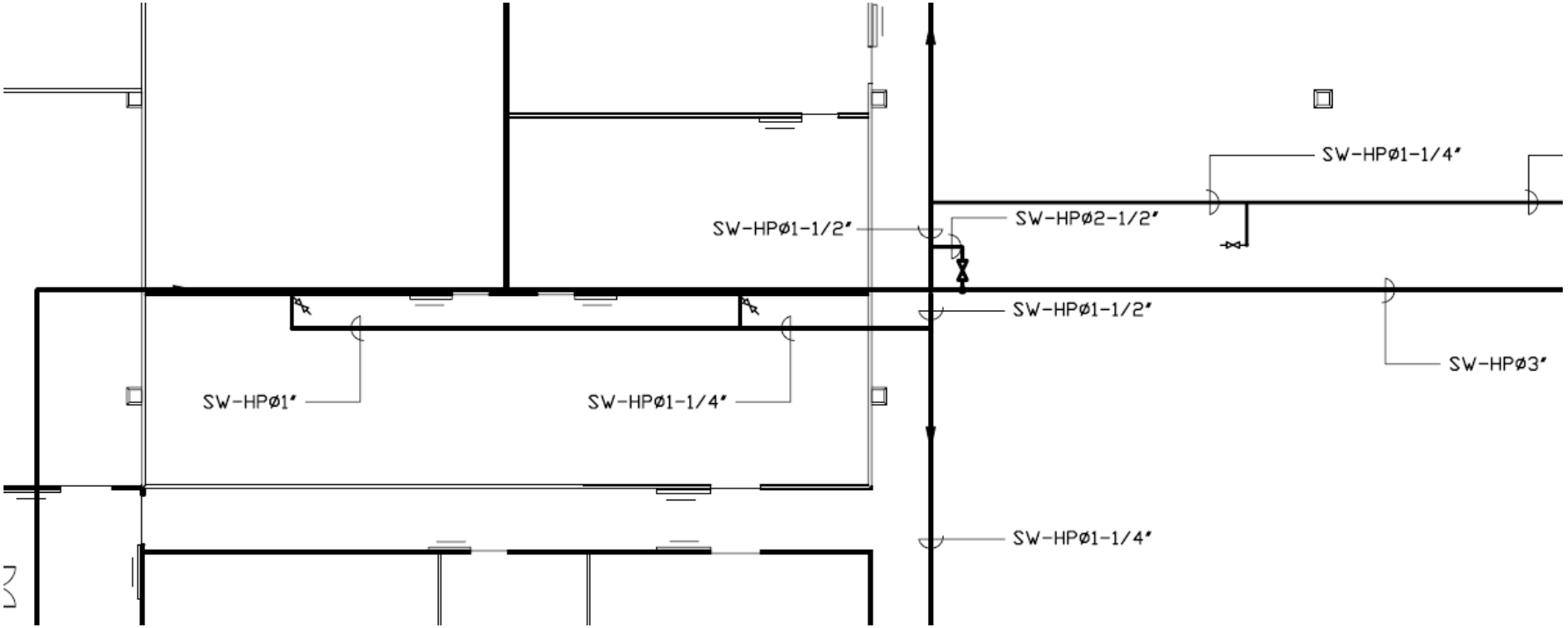


AUTODESK®
REVIT® MEP



Mechanical/Electrical/Plumbing

DIMENSIONING



EXAMPLE
CONTENTS OF WORKING DRAWINGS

COVER
LIST OF DRAWINGS
LIST OF SYMBOLS
EQUIPMENT SCHEDULE
MASTER PLAN
UTILITY OUTLETS (OPTIONAL)
OVERALL SCHEMATIC (OPTIONAL)
SYSTEM1

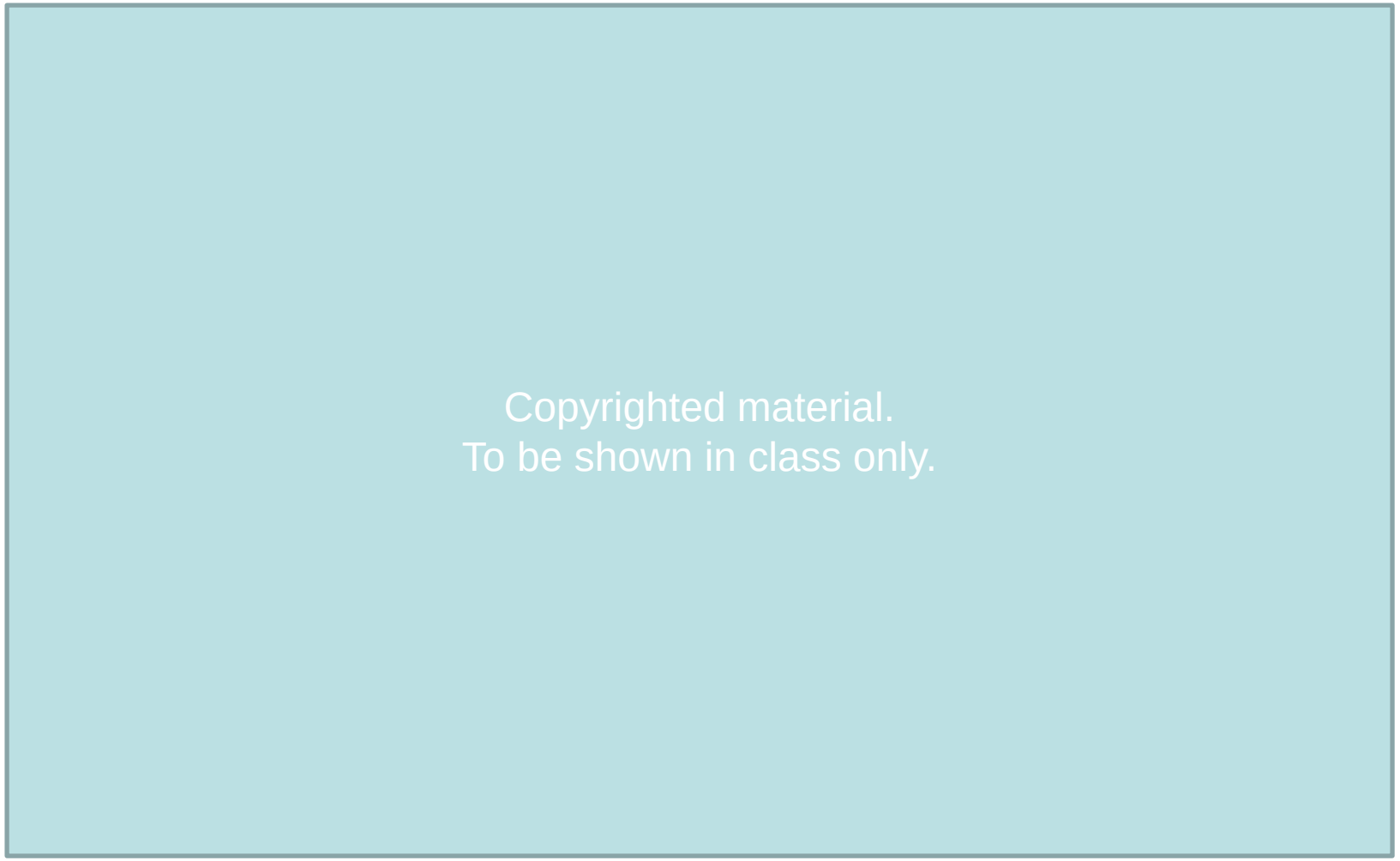
- SCHEMATIC DIAGRAM
- FLOORPLAN(S)
- DETAIL/SECTION

SYSTEM2

- SCHEMATIC DIAGRAM
- FLOORPLAN(S)
- DETAIL/SECTION

…

COVER



LIST OF DRAWINGS

PLUMBING SYSTEM

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P-08	UTILITY OUTLET (GROUND FLOOR PORTION D)
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P-30	RC GUTTER W/STEEL GRATING COVER, 0.50 (W)
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DWG. No.	DESCRIPTION
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	TYPICAL DETAILS
	TYPICAL DETAILS (SD06, SD11, SD04, SD05)
	TYPICAL DETAILS (SD14, SD15, SD163, SD25)
	TYPICAL DETAILS (SD83, SD84, SD87, SD93, SD94, SD95, SD106, SD109)
	TYPICAL DETAILS (SD122, SD07, SD08, SD09, SD10, SD17, SD06, SD18)
	TYPICAL DETAILS (SD80, SD21, SD82, SD83, SD96, SD89, SD30, SD112)
	TYPICAL DETAILS (SD35, SD48, SD54, SD160, SD63, SD161, SD80, SD81)
	TYPICAL DETAILS (SD109, SD110, SD111, SD114, SD115, SD117, SD118, SD123)

Project : TA32 | DWG. No.
Title : LIST OF DRAWINGS | P-01
Scale : N/A | Date : 12 July 2006

LIST OF SYMBOLS

PLUMBING AND F

ABBREVIATIONS & LETTER SYMBOLS

SYMBOLS	DESCRIPTION
ACP	ASBESTOS CEMENT PIPE
AFF	ABOVE FINISHED FLOOR
ANN	GRAPHIC ANNUNCIATOR BOARD
@	DIRECT
BSP	BLACK STEEL PIPE
BT	BATH TUB
°C	DEGREE CELCIUS
CBD	CONTINUOUS BLOWDOWN DRAIN PIPE
cm.	CENTIMETRE
CO	CLEANOUT
CW	COLD WATER PIPE
CW-HP	HIGH PRESSURE COLD WATER
D	DRAIN PIPE
EA	EACH
ELV	ELEVATION
F	FIRE PROTECTION PIPE
°F	DEGREE FAHRENHEIT
FC	FAUCET
FCO	FLOOR CLEANOUT
FD	FLOOR DRAIN
FDC	FIRE DEPARTMENT CONNECTION
FFD	FUNNEL FLOOR DRAIN
FH	FIRE HYDRANT
FL.	FLOOR
FM	FACTORY MUTUAL
FOR	FUEL OIL RETURN PIPE
FOS	FUEL OIL SUPPLY PIPE
FT	FEET
G	GAS PIPE
GPM	GALLON PER MINUTE
HD	HOSE BIBB
HDPE	HIGH DENSITY POLYETHYLENE
HP	HORSE POWER
HW	HOT WATER PIPE
HWR	HOT WATER RETURN PIPE
kW	KILOWATT
LAV	LAVATORY
m.	METRE
MAX	MAXIMUM
MH	MAN HOLE
MIN	MINIMUM
mm.	MILLIMETRE
NC	NORMALLY CLOSED
NFPA	NATIONAL FIRE PROTECTION ASSOCIATION
NIC	NOT IN CONTRACT
NO	NORMALLY OPENED
NO.	NUMBER
PD	PLANT DRAIN
PSI	POUND PER SQUARE INCH
PVC	POLYVINYL CHLORIDE
RC	REINFORCE CONCRETE
RCP	REINFORCE CONCRETE PIPE
RD	ROOF DRAIN
RL	RAIN LEADER PIPE
RO	REVERSE OSMOSIS WATER PIPE

SYMBOLS	DESCRIPTION
ROWC	REVERSE OSMOSIS 5 °C WATER PIPE
RPM	REVOLUTIONS PER MINUTE
S	SOIL PIPE
SW	SOFT WATER PIPE
SWRW	SOFT WATER RETURN 46 °C PIPE
SWSW	SOFT WATER SUPPLY 46 °C PIPE
SH	SHOWER
SK	SINK
ST	STEAM PIPE
SV	SUPERVISORY SWITCH
SVD	SIDE WALL DRAIN
SW-F	FILTERED SOFTENED WATER PIPE
SW-F-46C	46 ° C FILTERED SOFTENED WATER
SW-F-HP	HIGH PRESSURE FILTERED SOFTENED
TYP	TYPICAL
UL	UNDERWRITES LABORATORIES INC.
UR	URINAL
V	VENT PIPE
W	WASTE PIPE
W/	WITH
WC	WATER CLOSET
WHA	WATER HAMMER ARRESTOR
YCO	YARD CLEANOUT
1.00%	SLOPE 1:100

FIRE PROTECTION SY

SYMBOLS	DESCRIPTION
FH	FIRE HYDRANT
FDC	FIRE DEPARTMENT CONNECTION
	FIRE HOSE CABINET
	CO2 PORTABLE EXTINGUISHER
	ALARM VALVE
	FLOW SWITCH
	OS&Y GATE VALVE
	PENDENT SPRINKLER HEAD
	UPRIGHT SPRINKLER HEAD

SYMBOLS	DESCRIPTION
	BLIND FLANGED END
	CAP END
	ELBOW 45 DEGREE
	ELBOW 90 DEGREE
	LATERAL
	ELBOW TURNED DOWN
	ELBOW TURNED UP
	FLANGED PIPE CONNECTION
	TEE
	TEE , OUTLET DOWN
	TEE , OUTLET UP
	TEE , BOTTOM CONNECTION
	TEE , TOP CONNECTION
	FLOW IN DIRECTION OF ARROW
P D	PITCH TO DRAIN
	PRESSURE GAUGE
	FLEXIBLE CONNECTION

Project : TABP	DWG. No.
Title : PLUMBING AND FIRE PROTECTION SYSTEM SYMBOLS	38
Scale : N/A	Date : 12 JULY 2006

MATERIAL AND EQUIPMENT SCHEDULE

PUMP SCHEDULE

EQUIPMENT NO.	SERVICE	FLOWRATE (CMH)	TDH (M)	MAXIMUM MOTOR SPEED (RPM)	APPROX. MOTOR SIZE (KW)	V/PH/Hz	PUMP TYPE	REMARK	LOCATION
BP-01	BOOSTING SYSTEM FOR SV FROM SW-WATER STORAGE	50	100	3000	3x11	380/3/50	PACKAGED BOOSTER PUMP WITH DIAPHRAGM PRESSURE TANK	THREE PUMP PARALLEL ALTERNATE OPERATION	PUMP HOUSE
BP-02	TANK BOOSTING SYSTEM FOR SV FROM SW-WATER STORAGE	40	100	3000	3x7.5	380/3/50	PACKAGED BOOSTER PUMP WITH DIAPHRAGM PRESSURE TANK	THREE PUMP PARALLEL ALTERNATE OPERATION	PUMP HOUSE
WTP-01	WASTE WATER TRANSFER FROM GREASE TRAP TANK TO CENTRAL WASTE WATER TREATMENT PLANT	110	40	1450	45.0	380/3/50	SELF-PRIMING CENTRIFUGAL PUMP, BELT DRIVE		GREASE TRAP TANK
WTP-02	WASTE WATER TRANSFER FROM GREASE TRAP TANK TO CENTRAL WASTE WATER TREATMENT PLANT	110	40	1450	37.0	380/3/50	SELF-PRIMING CENTRIFUGAL PUMP, BELT DRIVE		GREASE TRAP TANK

NOTE : EE POWER SUPPLY WILL BE PROVIDED BY EE CONTRACTOR TO CONTROL PANEL OF EACH PUMP

SCHEDULE FOR PIPING MATERIAL

SYSTEM	SPECIFICATIONS
1. SUPPLY WATER PIPE	
CV	Galvanized Steel Pipe Medium Class, Valve Class 150 Psi
CV Underground	HDPE PN10
CV Below Ceiling (Visible)	SUS304 Pipe Schedule 40, Valve Class 150 Psi
SV	SUS304 Pipe Schedule 40, Valve Class 150 Psi
SV Underground	HDPE PN10
SV Below Ceiling (Visible)	SUS304 Pipe Schedule 40, Valve Class 150 Psi
CW-HP	Black Steel Pipe Schedule 40, Valve Class 300 Psi
CW-HP Below Ceiling (Visible)	SUS304 Pipe Schedule 40, Valve Class 300 Psi
SW-HP	SUS304 Pipe Schedule 40, Valve Class 300 Psi
SW-HP Below Ceiling (Visible)	SUS304 Pipe Schedule 40, Valve Class 300 Psi
CW-HC	SUS304 Pipe Schedule 40, PU Foam Insulation, SUS304 Cladding, Valve Class 150 Psi
CW-HC	SUS304 Pipe Schedule 40, PU Foam Insulation, SUS304 Cladding, Valve Class 150 Psi
SW-SC	SUS316 Food Grade Pipe, Valve & Fittings, PU Foam Insulation, SUS304 Cladding, Valve Class 150 Psi
2. RAIN WATER PIPE	
- GALVANIZED STEEL PIPE (MEDIUM CLASS)	
- HDPE PIPE (PN 6) FOR UNDER GREENS	
- HDPE PIPE (PN 10) FOR UNDER ROAD	
3. WASTE, SOIL AND VENT	
- PVC (CLASS 13.5) UNDER BUILDING	
- HDPE PIPE (PN 6) FOR UNDER GROUND	
- HDPE PIPE (PN 10) FOR UNDER ROAD	
4. PIPE FROM GREASE TRAP TANK TO EFFLUENT PIPE	
- HDPE (PN 10)	
- VALVE CLASS 150 psi	
5. FIRE PROTECTION PIPE	
- BLACK STEEL PIPE (SCHEDULE 40)	
- HDPE PIPE (PN 16) FOR UNDER GROUND AND UNDER ROAD	
- VALVE CLASS 175 psi, UL LISTS AND/OR FM APPROVED	

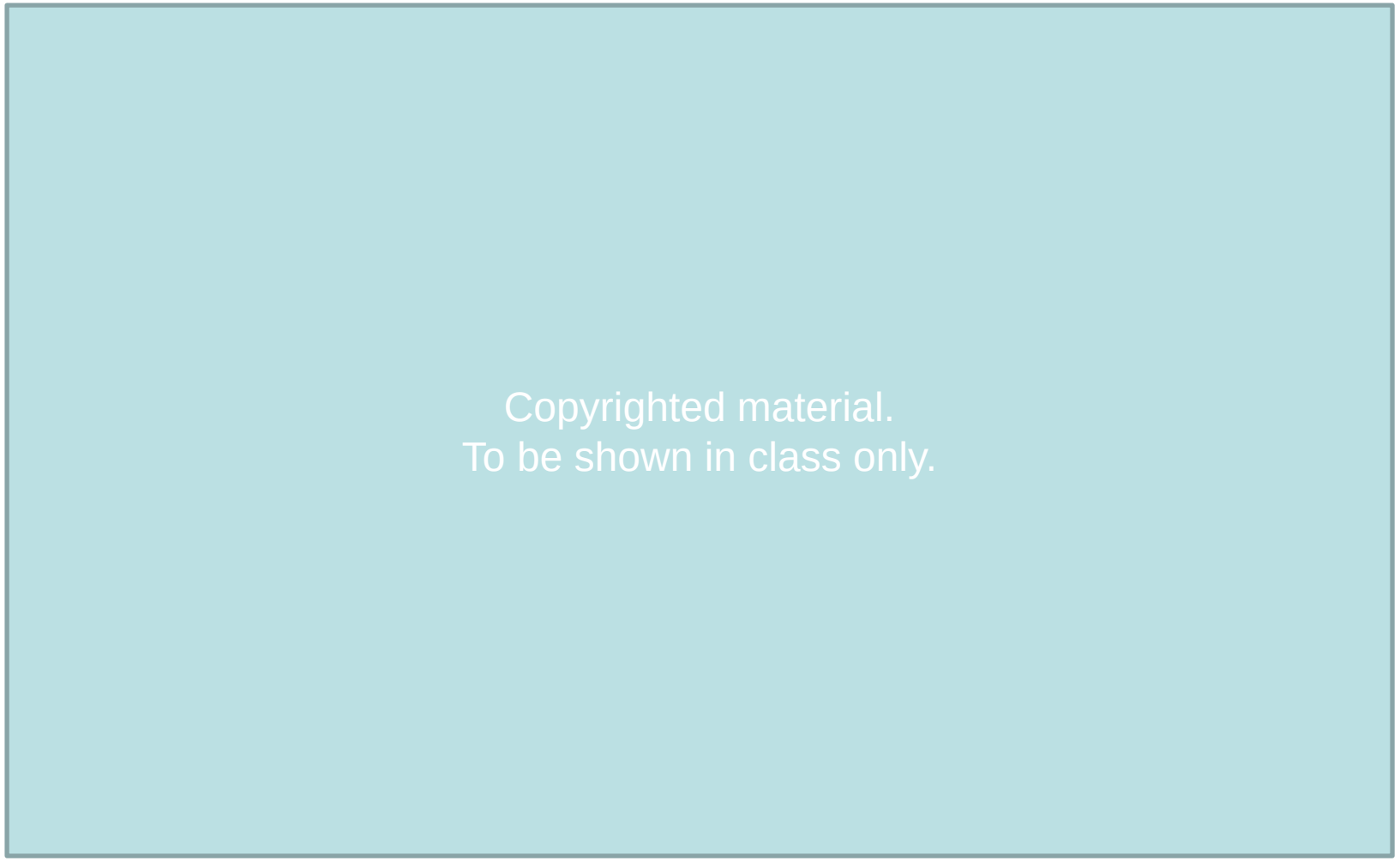
NOTE : SUPPLY WATER LINE MUST BE CHANGED TO SS304 PIPE BEFORE RUN DOWN THROUGH CEILING PANEL TO OUTLET. BALL VALVE, HANGER AND SUPPORT IN PRODUCTION AREA ARE ALL STAINLESS STEEL. ALL PIPE, PU FOAM INSULATED MUST BE PROTECTED BY STAINLESS STEELSUS CLADING STAINLESS STEEL. FLASHING MUST ALSO BE APPLIED.

FIRE PUMP SCHEDULE

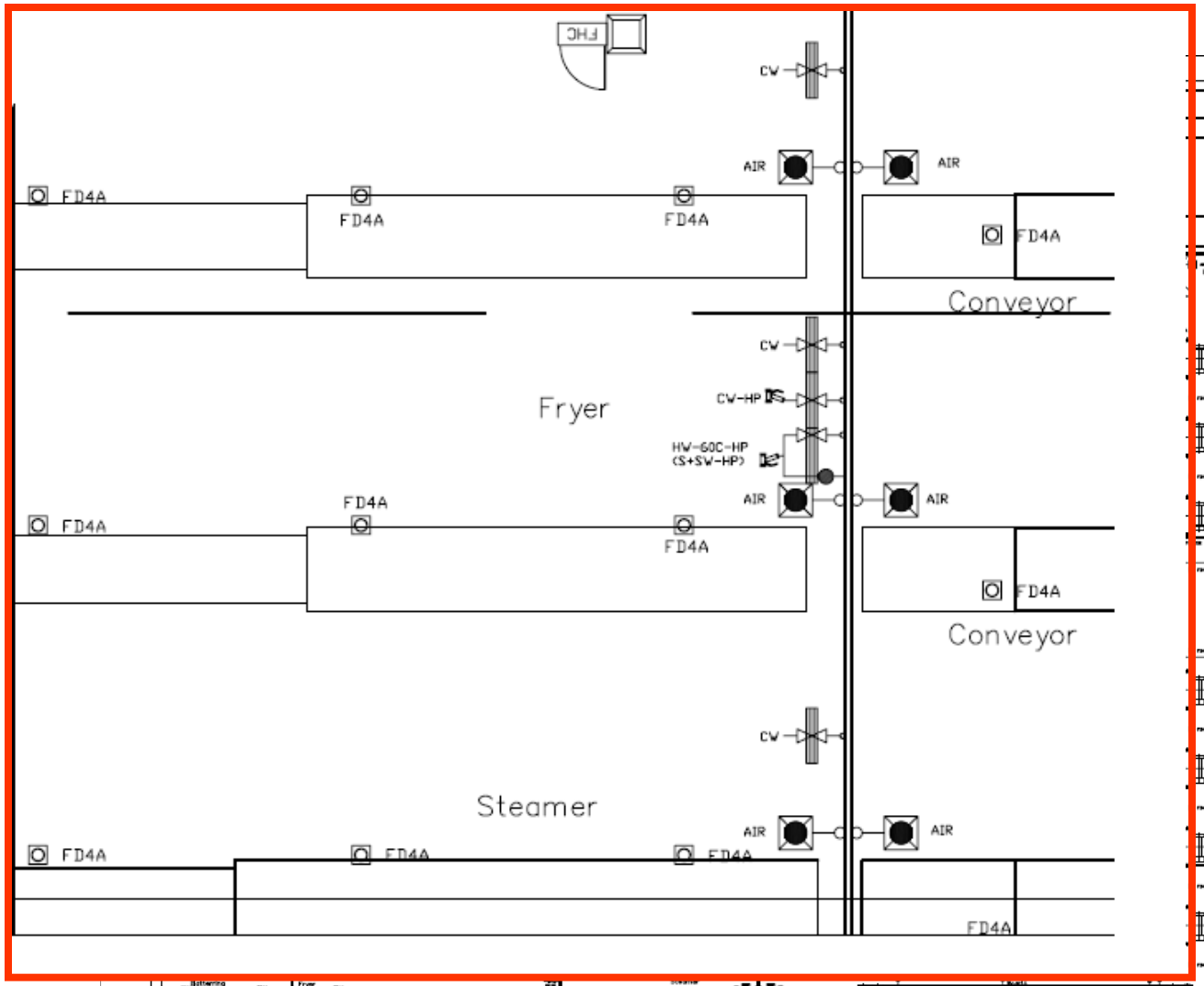
DESCRIPTION	FIRE PUMP (FP)	JOCKEY PUMP (JP)	REMARKS
TYPE OF PUMP	HORIZONTAL SPLIT CASE CENTRIFUGAL	REGENERATIVE TURBINE VANE	1) FIRE PUMP SHALL BE IN ACCORDANCE WITH
TYPE OF DRIVER	DIESEL ENGINE	ELECTRIC MOTOR	THE LASTEST NFPA 20 STANDARD FOR THE INSTALLATION
LOCATION	PUMP ROOM	PUMP ROOM	OF CENTRIFUGAL FIRE PUMP AND SHALL BE UL. LISTED
RATED CAPACITY (GPM)	1,250	30	AND/OR FM APPROVED.
RATED HEAD (FEET)	150	150	2) FIRE PUMP CONTROLLER SHALL BE UL LISTED
NO. OF STAGE	SINGLE-STAGE	SINGLE OR MULTI-STAGE	AND/OR FM APPROVED.
TYPE OF SEAL	PACKING	MECHANICAL	3) JOCKEY PUMP CONTROLLER SHALL BE BUILT
PUMP SPEED (RPM)	≤3000	≤3000	TO NEMA INDUSTRIAL STANDARDS.
PUMP EFFICIENCY (%)	≥60	≥40	
ELEC. CHARACTERISTIC (V/Ø/Hz)	-	380/3/50	
APPROX. MOTOR kW (HP)	-	7.5 kW (10HP)	
APPROX ENGINE BHP	180 HP	-	
PUMP STARTING PRESSURE (PSIG)	100	135	
PUMP STOPING PRESSURE (PSIG)	MANUAL	150	

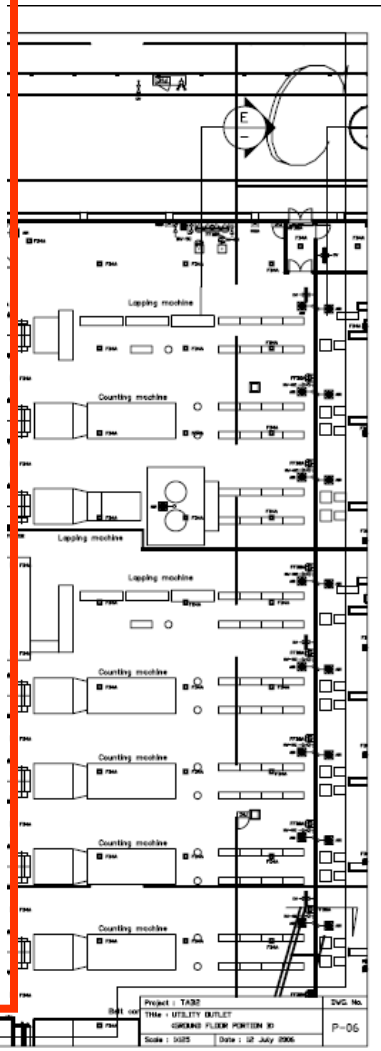
Project : TA32	DWG. NO.
Title : EQUIPMENT SCHEDULE AND PIPING MATERIALS	
Scale : N/A	Date : 12 JULY 2006

MASTER PLAN

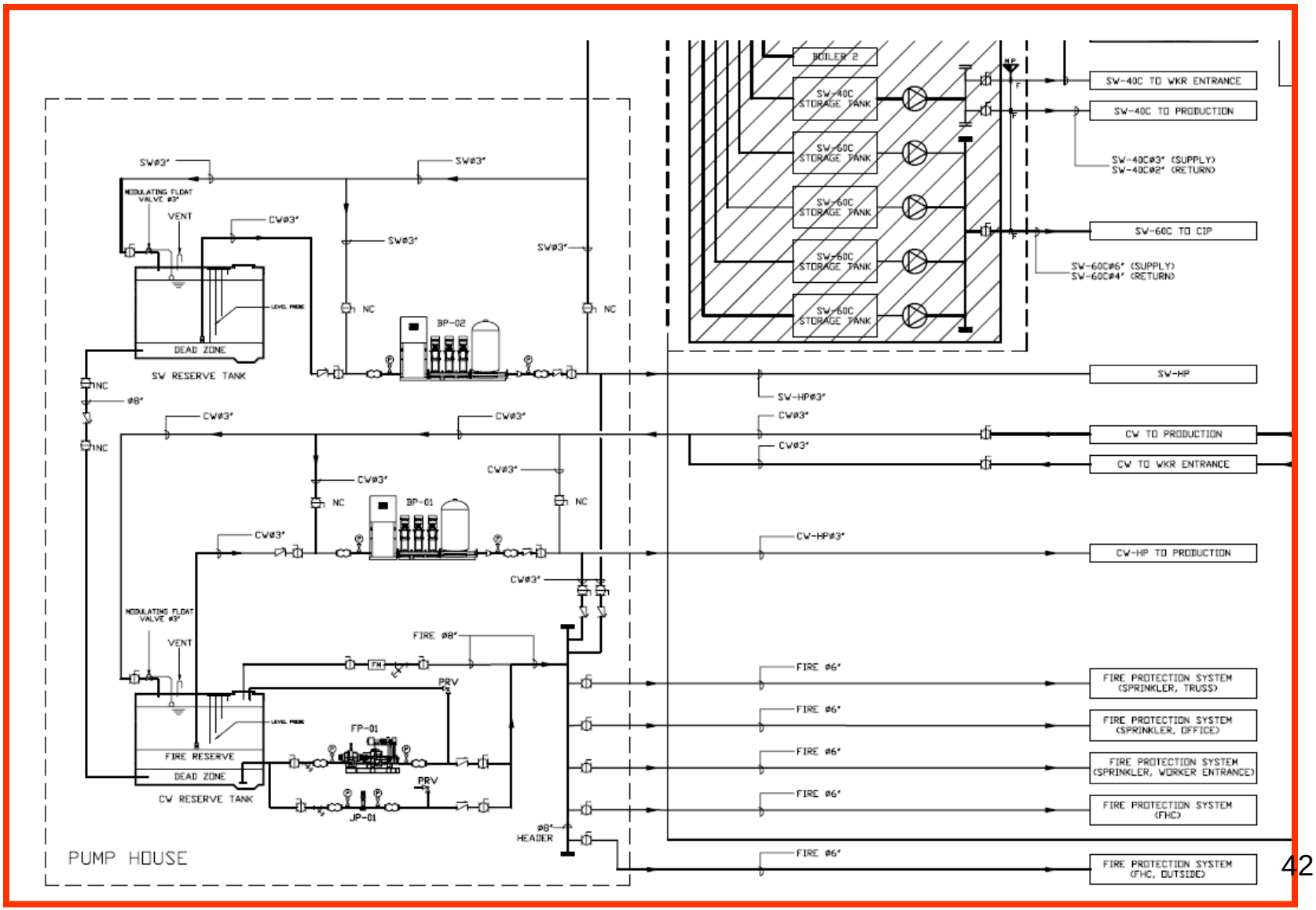


UTILITY OUTLETS (OPTIONAL)

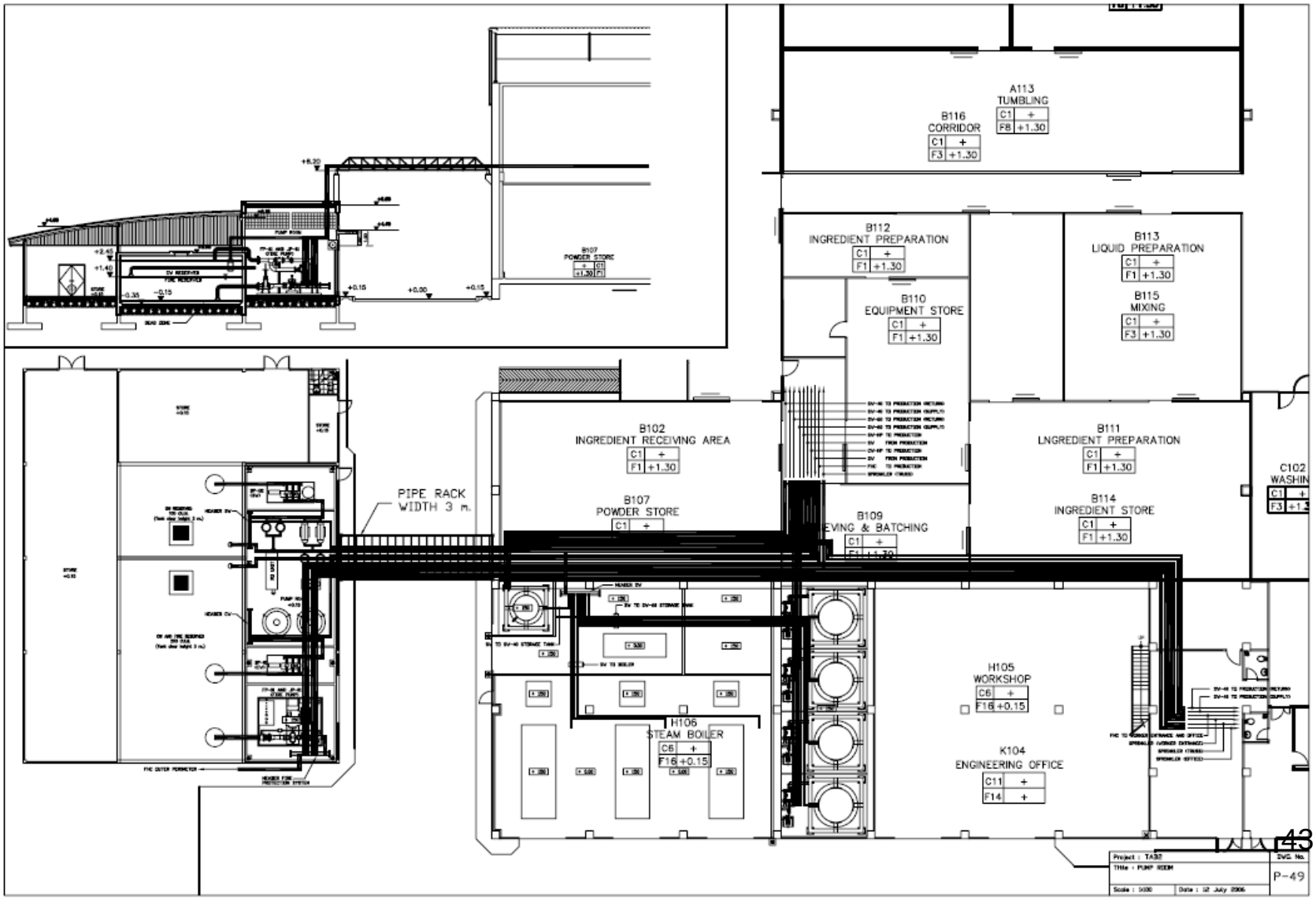




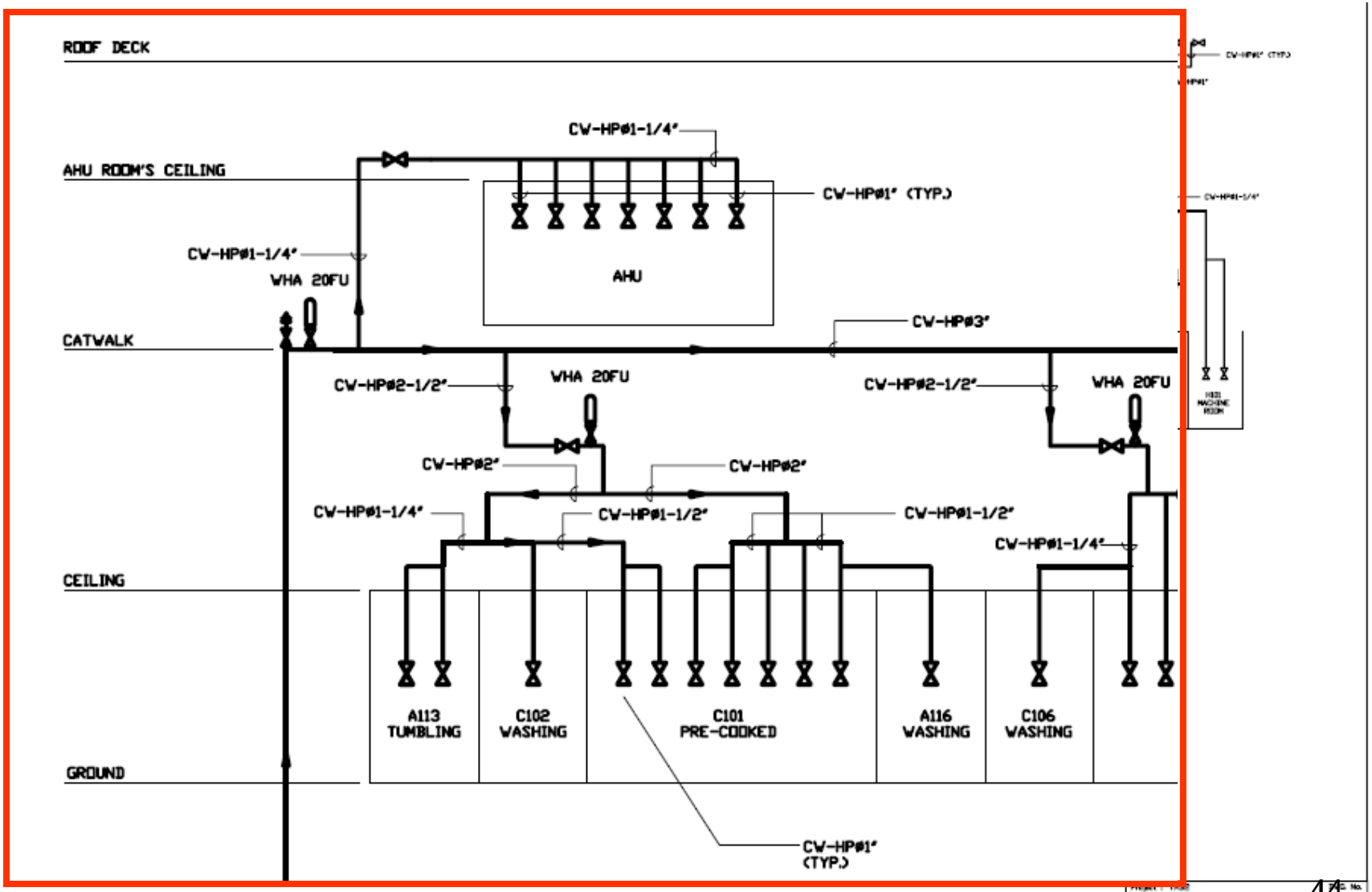
OVERALL SCHEMATIC (OPTIONAL)



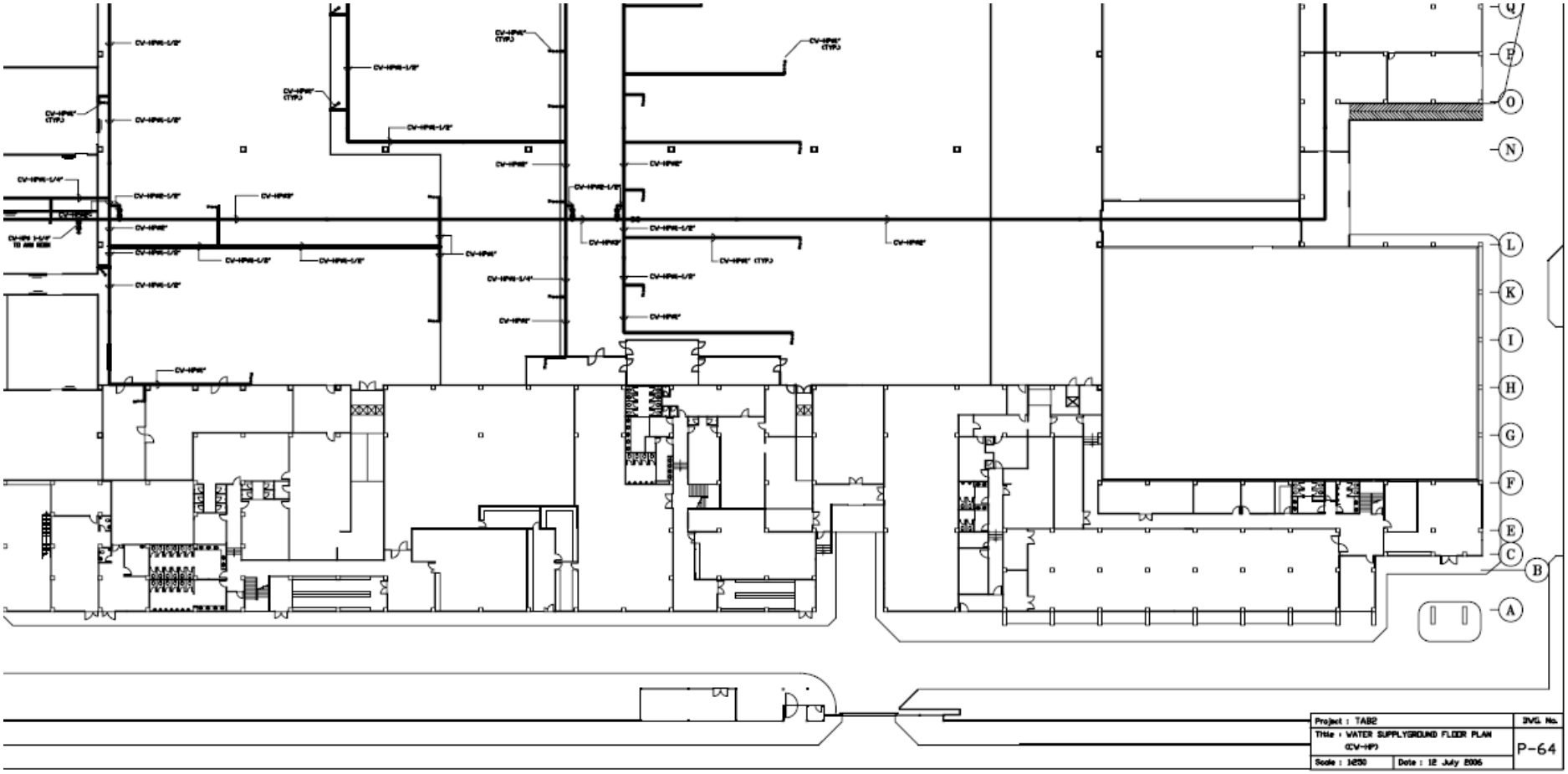
MACHINE ROOM LAYOUT



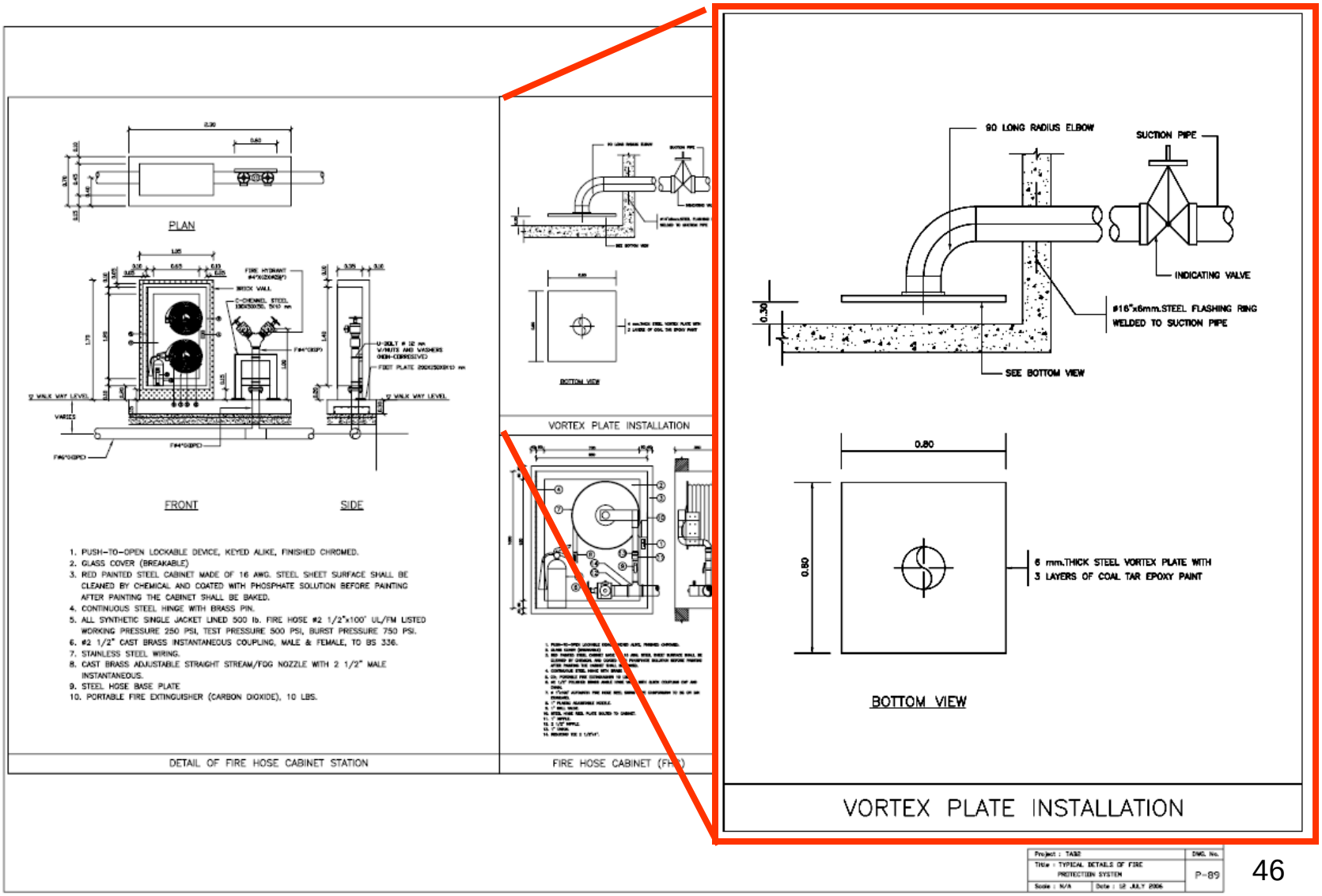
SYSTEM1 SCHEMATIC



SYSTEM1 FLOOR PLAN



TYPICAL DETAILS



2. COST ESTIMATION

B.O.Q.

BILL OF QUANTITY

MATERIALS TAKE-OFF FROM DRAWINGS

MATERIAL + LABOR + PROFIT

B.O.Q.

ITEM	DESCRIPTION	QTY.	MATERIAL		LABOUR		TOTAL
			U COST	COST	U COST	COST	
1	CW Piping System (GSP Class-M with Valves Class150psi for Piping System Above Ceiling & SUS304 Sch40 with SUS Valve Class 150psi for Piping System Below Ceiling)						
	Pipe SUS304 (Below Ceiling)						
	DIA. 1/2"	-					
	DIA. 3/4"	285	330	94,050	84	23,940	117,990
	DIA. 1"	-					
	DIA. 1 1/4"	-					
	DIA. 1 1/2"	-					
	DIA. 2"	0	993	-	105	-	-
	DIA. 2-1/2"	-					
	DIA. 3"	-					
	DIA. 4"	0	2,950	-	158	-	-
	Fitting SUS304 (Below Ceiling)						
	DIA. 1/2"	-					
	DIA. 3/4"	1	3,675	3,675	1,838	1,838	5,513
	DIA. 1"	-					
	DIA. 1 1/4"	0	5,880	-	2,940	-	-
	DIA. 1 1/2"	-					
	DIA. 2"	0	9,765	-	5,565	-	-
	DIA. 2-1/2"	-					
	DIA. 3"	-					
	DIA. 4"	0	14,385	-	7,980	-	-

B.O.Q. (cont'd)

	1 Year Service And Warrantee						
	Main Office Overhead						
	Site Office And Store Expenses						
	Site Office Utility Expenses						
	Crane						
	Watchman & Guard						
	Accommodation						
	Transportation						
	Project Insurance						
	LG Fee & Bond's						
	Other Expenses						
	Profit						
	SUBTOTAL			80,000		20,000	100,000
	VAT						
	TOTAL			417,401		151,397	589,549

SCOPE (MAY VARY)

DESIGNERS

PRODUCE TERMS OF REFERENCE (T.O.R.)
DRAWING + TECHNICAL SPECIFICATIONS
COST ESTIMATION

CONSULTANTS

ARRANGE BIDDING
SITE SUPERVISION
MATERIALS/EQUIPMENTS/ SHOP DRAWINGS APPROVAL
PROJECT MANAGEMENT

CONTRACTORS

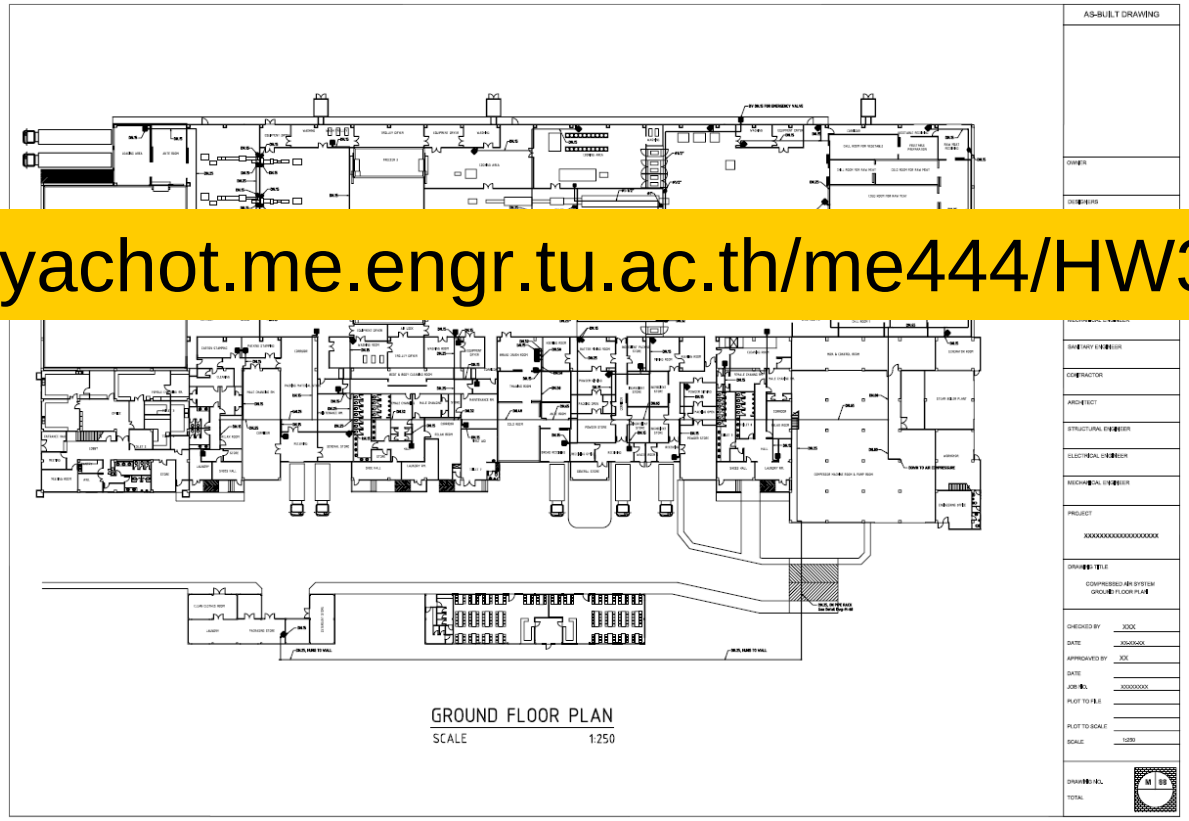
GET THINGS DONE ACCORDING TO THE T.O.R.
PREPARE SHOP DRAWING FOR APPROVAL BEFORE INSTALLATION
PREPARE AS-BUILT DRAWING/OPERATION MANUAL AFTER INSTALLATION COMPLETED
CONDUCT SYSTEM COMISSIONING

OWNERS

SPECIFY REQUIREMENTS
FINAL APPROVAL
PAY

HOMEWORK

Draw schematic diagram of the SW-F-HP piping system.



dulyachot.me.engr.tu.ac.th/me444/HW3.dwg