DESIGN GUIDE FOR:

"LAYOUT & PLOT PLAN"

CONTENTS

1. The Basics Of Plant Layout Design

Plant layout design plays an important part in the design and engineering phases of any industrial facility . This chapter discusses the role and responsibilities of the plant layout designer , provides advice on how to use project data , describes the timing of various activities , offers an approach to a basic piping design layout and lists abbreviations and common terminology . Subsequent chapters cover plant layout specifications, major equipment layouts commonly found in such facilities , pipe rack layout, underground design , and instrumentation.

2. The Plant Layout Designer

The plant layout designer is skilled primarily in the development of equipment arrangements and piping layouts for process industries. The position offers an opportunity to demonstrate technical ability along with a creative talent and common-sense approach to problem solving. Process facilities must be designed while adhering to maintenance , safety and quality standards ; moreover , the design must take constructability , economics and operations into account . Although the tools to achieve these goals are changing from pencil and paper to computer graphics terminals the responsibilities of the plant layout design remain the same.

The plant layout designer must develop layout documents during the conceptual and study phases of a project. The skills needed include :

- Common sense and the ability to reason.
- Knowledge of what a particular plant is designed to do.
- A general understanding of how process equipment is maintained and operated.
- The ability to generate a safe , comprehensive layout within a specified time and with consideration toward constructability and cost-effectiveness.
- Creativity .
- Sufficient experience to avoid reinventing the wheel.
- Knowledge of the principal roles of other design and engineering groups and the ability to use input from these other disciplines.

- The ability to resolve unclear or questionable data .
- Willingness to compromise in the best interest of the project.
- The ability to generate clear and concise documents.
- The ability to defend designs when challenged.

3. Principal Functions

The principal functions of the plant layout designer include the conceptual and preliminary development of process unit plot plans , sometimes referred to as equipment arrangements ; the routing of major above and below-grade piping systems ; and the layout of equipment and its associated infrastructure. Plot plans show the positions of major units and equipment within units and their associated infrastructure. Creating a well-designed facility involves meeting all client specifications and local government codes and regulations and adhering to design engineering practices with the planning plot plan as a basis , the following functions are a standard part of the plant layout designer's activities :

- Setting all equipment locations – This activity includes input from construction on erection sequences or on special problems associated with setting large pieces of equipment. Choosing equipment locations includes setting coordinates in two directions and finalizing equipment elevations , whether they are centerline , tangent line , or bottom of base plate .
- Designing all structures and positioning the associated stairways , ladders , and platforms – In general , the designer makes provisions to satisfy all operational ,maintenance, and safety requirements for access to and clearance around equipment .
- Planning unobstructed areas for necessary steel members or structures that facilitate all plant maintenance requirements.
- Establishing all equipment nozzle locations satisfy all process , utility and instruments equipments.
- Locating all safety items (e.g. fire hydrants monitors , and safety shower stations).
- Locating all miscellaneous items (e.g. , filter silencers , and analyzer houses).

These activities must be closely coordinated all the plant design and construction participant volved in the engineering and construction phase project to reduce costly rework and enable the layout designer to generate the optimum design schedule.

4. Project Input Data

Although there is a vast amount of input data throughout the life of a project , the data basically follow three distinct categories :

- Project design data – Is supplied by the client or project engineering.
- Vendor data – Pertains to equipment and specialty bulk items.
- Internally generated engineering data.

These are discussed in the following sections.

Project design data This includes the geographic location of the plant ; its proximity to roads , railways and waterways ; local codes and regulations . Topography ; and climatic conditions. The project design data also specifies whether the project is within an existing facility or is a new site. This information is generally required during the project's plot plan development phase.

Vendor data All purchased equipment and specially bulk items (e.g. , pumps , compressors , air coolers , furnaces , control and safety valves , level instruments , strainers , and silencers) require preliminary vendor drawings for the development of piping layouts . Final certified drawings are usually not required until the detail phase.

Internally generated engineering data This data is typically generated by the supporting disciplines within the designer's organization. An example of such information is shown in Fig.LPP 1. This information is eventually superseded by certified vendor drawings but is of sufficient quality and definition to use during the study phase of the project.

5. The Logic Diagram

The design of any processing plant is usually accomplished in three phases : conceptual , study , and detail conceptual designs are made when sketchy or minimal information is used to prepare an abstract arrangement of a plot plan or an equipment and piping layout . Preliminary , or study phase , designs are made with unchecked or uncertified data to design a facility in sufficient detail so that the documents produced can be used for detail design , confirmation of purchased equipment , and the purchase of bulk materials. In the detail phase, all designs are finalized. The designs use such checked data as steel and concrete drawings , hydraulics and certified vendor drawings for equipment , valves , and instruments .

The major activities of the plant layout designer to achieve an optimum plant configuration taker place during the study phase of a project. Although project schedules often dictate variations in this approach , it is intended to be an optimum condition for the most effective use of staff time. The study phase can make or break a project . Working out of sequence is acceptable within reason , but if it is overdone , a project will never recover during the detail phase. The ideal situation for speed and quality is to do the job right the first time.

6. Project Input Data

Each plant layout designer develops an individual layout philosophy. Although conditions (e . g.,client specifications , schedule constrains , and availability information) may change significantly among projects designer's style remains consistent . One basic remember is to avoid designing one line at a member that is , routing a line from one piece of equipment to another before thinking about the next one. Although it is possible to complete an area design useing approach , the result is a lack of consistency.

An overview of all the piping within a given area should be completed before the designer proceeds with the final arrangement. This can be achieved through close review of the piping and instrumentation diagrams and freehand sketching of major piping configurations to ensure that the piping will be routed in an orderly manner.

7. Plan View Layout

Both arrangements shown in Fig.LPP 2 are workable piping layout for the given equipment. The design in plan A is the one-line-at-a-time approach. Along with requiring more pipe fittings and steel in support 1 , it lacks consistency. Plan B was developed as a whole unit. Lines running to the nozzles on drums D and E are on the outside of the pipe rack and peel off first with flat piping turns . The lines to exchangers A, B, and C are located to the center of the rack and can also peel off in most cases.

This approach saves fittings and requires a shorter steel beam to support the piping . It should be noted that the use of flat turns in piping is not recommended if there is a likelihood of future expansion in an area. The alternative to accommodate future piping running north at the same elevation is to change elevation for the piping running east and west to the drums. Although it is not always necessary to plan for future expansion , it can often be done with very little additional effort and cost. Each area should be the through on a case-by-case basis.

8. Elevation Layout

Fig.LPP 3 Shows two workable piping layouts key difference is that the arrangement on the shows piping running at too many elevation with little effort , this can be corrected , as shown in right-hand view. Adding support steel for this preferred design would require only minimal effort. The view on the left , however , would require additional engineering time and additional steel cost .

9. Diagonal Piping Runs

When lines are run in a congested area , a basic rule to follow is to change the elevation to avoid interference with other lines when lines are to be routed perpendicular to most adjacent piping. The arrangement shown in plan A of Fig.LPP 4 has a minimal offset dimension , X. Running the line at the same elevation is acceptable if it does not block the passage of a large number of other lines. In plan B , dimension Y would interfere with too many lines and should run at a different elevation , as shown. There is no absolute rule except that judgment should be used to produce a neat and orderly layout as well as to occasionally save pipe fittings when possible.

10. Valve Manifolds

The layout of valve manifolds is another opportunity to exercise consistency of design. Layout A of Fig.LPP 5 uses an excessive number of fittings and indicates a lack of proper planning . With a little thought and extra effort , a less expensive and more practical design can be generated , as shown in layout B. Certain piping specification may restrict the use of branch connections in lieu of reducers , but this option should be considered if at all possible .

11. Use of Space

The effective use of plant real estate provides plant operations and maintenance personnel with the maximum amount of room in a plant. Which in most cases can be very congested Fig.LPP 6 shows some typical misuses of valuable real estate.

For example the steam trap assembly shown on the left is commonly designed in the engineering office. This arrangement for a thermodynamic steam trap is spread out over an area of approximately 27 in (690 mm) in length. Although this area may not seem excessive for one trap assembly , it can be avoided completely by installing the trap and strainer in the vertical leg of the piping , as shown on the right. An additional drain may be required , but this arrangement should be considered as a space-saving alternative. The steam tracing manifold in the left-hand sketch is another common engineering office approach that wastes valuable plant space. If a vertical manifold that is supported from the column is used , additional space is available for other piping systems or operator access.

The client must live with the plant long after the engineering and construction phases are over. The operators will be walking through the facility each day and will be continually reminded of who took the time and effort to plan the project thoroughly , and they will keep that in mind when the next expansion planned.

12. Terminology

The terminology used in text and illustrations is defined in the following sections .

Process flow diagram This document schematically shows all major equipment items within a plant and how they are linked together by piping , ducts , and conveyors . It shows equipment number , flow rates and operating pressures and temperatures and is use to prepare the mechanical flow diagrams (i.e. piping and instrumentation diagrams). It is also used to prepare conceptual and preliminary plot plans.

- **Equipment list** An itemized accounting list by class of all equipment to be used on a project, this document gives the equipment item numbers and descriptions and is generally furnished by the client or project engineering.
- **Piping and instrumentation diagrams** These documents schematically show all process , utility , and auxiliary equipment as well as piping , valving , specify items , instrumentation and insulation , and heat tracing requirements.
- **Piping specification** This document lists the type of materials to be used for pipes , valves and fittings for each commodity in a plant. This listing is base on pressure , temperature , and the corrosive nature on the flow medium. It also describes pipe wall thicknesses how branch connections are made , and itemized codes that are used for ordering materials.
- **Line run** This is the physical route a pipe take between any tow points as set by the plant layout designer.
- **Planning study or layout drawing -** This is an initial graphic piping plan. It is usually not a finished document, nor is it deliverable to a client. This drawing shows all equipment in a given area to scale and includes major process and utility piping systems, significant valving , and instruments. It notes exact equipment locations and elevations, all nozzles , platform and ladder requirements and any pipe support that affects the design of equipment or structure other disciplines. Fig.LPP 7 is a typical example planning study.
- **Heat Racing -** In many processes, equipment , instruments, and piping systems require externally applied heat. This heat may be applied by electrical tracing leads attached to the item or line or through a small bore pipe or tubing that carries steam or other heating media (e.g. hot oil) . An

example of a steam-traced line is shown in**.** Fig.LPP 8

- **Inline** – This term refers to a component that is placed either inside or between a pair of flanges as opposed to one attached to a piece of pipe or equipment . An example of inline instrumentations is shown in. Fig.LPP 9
- **Header Block Valves –** These valves isolate branch lines that are not usually provided with permanent access for plant operations personnel.
- **Header –** This line is the primary source of a commodity used by numerous pieces of equipment or service points in a plant. An example of a header arrangement is shown in. Fig.LPP 10
- **Branch -** The individual piping leads between headers and users are also illustrated in. Fig.LPP 10
- **Maintenance –** Equipment and its components require routine maintenance for continued reliability and safe operation. A plant layout designer must provide unobstructed space for service equipment and personnel to access and remove components without removing unrelated equipment and piping.
- **Operation –** Valves, instruments, and many types of equipment require frequent attention for operation. These items must be accessible without impairing the safety of plant personnel.
- **Safety –** The layout of any facility must enable plant personnel to exit a potentially hazardous area without Injury. Planning for safety includes adding roadways to provide access for fire fighters and equipment; strategically placing fire detectors and hydrants around the process unit; adding sufficient ladders and stairways at structures to meet OSHA requirements; locating furnaces with fired burners away from potential sources of gas leaks; and setting the height and location of vents to prevent injury to operating personnel.
- **Cost Effective –** Developing the most inexpensive layout may not translate into the most cost-effective design for the life of the plant. A cost effective design is the result of a balanced consideration of initial cost, safety , and long-term effects of a design on operations and maintenance.

  An example of cost-effectiveness is the layout of steam-driven gas compressors, Although a grade-mounted installation is initially less expensive to install, maintenance on such arrangements often requires the dismantling of all major piping systems. This can prolong plant downtime and translate into lost revenue for the client. Careful consideration should be given to all factors before the initially lowest-cost solution is chosen.

- **Gravity Flow –** When pockets must be avoided in a given piping system, the line is labeled "gravity flow" on the piping and instrumentation diagram. This often results in locating equipment in elevated structures instead of at grade, as shown in. Fig.LPP 11
- **Open System –** An open system is one in which the contents of a line are discharged and not recovered . Examples of this include a relief valve discharging into the atmosphere and a seam trap discharging onto the ground or into an open drain.
- **Closed Systems –** A closed system is one in which the contents of relief systems or steam trap condensates are recovered Examples of open and closed systems are shown in. Fig.LPP 12
- **Constructability -** Spending additional time and effort during the engineering phase of a project is often justified if it reduces initial construction staff time or decreases the potential for costly rework on piping layouts. Two examples of constructability are shown in. Fig.LPP 13 The suction piping of pump A is arranged fitting to fitting and does not allow the construction contractor any way to make an adjustment to a misalignment between the centerline of the vessel and the pump. Although the piping configuration is basically correct, it ignores the constructability of the overall layout. Adding a spool piece to pump B permits any adjustment that construction may require.

  The fitting-to-fitting arrangement at the air cooler inlet header poses a similar problem. Installation of large air coolers often makes it impossible for a pre-fabricated piping configuration to be bolted to the nozzles, unless a spool piece of reasonable length is included in the layout. Heat may be applied to the problem branch lines so they can be re-centered on the nozzles. The fitting-to-fitting configuration does not permit this flexibility to the constructor. Once again, the constructability factor should be considered.

13. Terms

Operator access is the space required between components or pairs of components to permit waling, operating valves, viewing instruments, climbing ladders or stairs , and safety ….. the unit in an emergency.

Maintenance access is the space required to service equipment in place or to remove the unit equipment or portions of equipment for off-site repair.

Equipment includes every component associated with the process plant (e.g. pumps, towers, heat exchangers, and compressors).

14. Equipment Arrangement

General plant arrangement must be consistent with prevailing atmospheric and site conditions as well as with local codes and regulations. Equipment must be grouped within common process areas to suit independent operation and shutdown. Equipment within process and off-site areas must be arranged to accommodate operational and maintenance access and to meet the safety requirements listed in. Fig.LPP 14 Unless required for common operation or safety, equipment is to be located in process sequence to minimize interconnecting piping .

Process units, buildings, and groups of off-site areas (e.g. tank farms) are serviced by auxiliary roads for maintenance and fire fighting . Equipment location must facilitate in-place maintenance by mobile equipment. Process equipment must be enclosed in shelters only when required by extreme climatic conditions or client preferences.

Fig.LPP 14

	1 FLARE	2ADMINISTRATIO	3 MAIN PLANT SUBSTATION	4 FIRE PUMPS & STATION	5 TRUCK & RAIL LEADING	6 UTILITY PLANTS	7 COOLING TOWERS	8 ATMOSPHERIC STORAGE TANK	9 LOW PRESSURE STORAGE TANK	10 HIGH PRESSURE STORAGE TANKS	11 MAIN PLANT THROUGH ROADS	12 BOUNDARIES & PUBLICROADS	13 FIRE HYDRANTS & MONITORS	14 MAIN PIPE WAYS	15 MAIN PLANT CONTROL HOUSE
1	400 GROU FLARE														
2		M													
3		M	NA												

Key :

A. Can be reduced to a minimum of 61 m by increasing height of flare

B. Boilers , power generators , air compressors

C. Monitor locations should be selected to

D. Greater than 200°C

E. less than 260°C

F. The diameter of the largest tank

G. Double the diameter of the largest tank

H. Maximum 75 m. minimum will vary

I. Blast resistant

M. Minimum to suit operator or maintenance access

NA. Not applicable

																16 PROCESS UNIT BATTERY LIMIT	17 PROCESS UNIT SUBSTATION	18 HYDROCARBON COMPRESSORS	19 DEASLTERS	20 REACTORS	21 HEAT EXOLONGERS	22 PROCESS PUMPS ABOVE AUTO IGNITION	23 PROCESS PUMPS BELOW AUTO IGNITION	24 TOWERS , DRUMS	25 AIR COOLERS	26 UNIT PIPE RACKS	27 PROCESS UNIT CONTROL HOUSE	28 FIRESHEATERS	29 UNIT ISOLATION VALVES	30 EQUIPMENT HANDLING NONFLAMMARS
4		15	30	M																										
5		60	60	45	M																									
6		45	30	30	60	M																								
7		45	60	30	60	45	15																							
8		75	75	105	75	75	75	F																						
9		105	105	105	105	105	105	75	G																					
10		105	105	105	105	105	105	75	G	G																				
11		M	15	7.5	15	15	15	45	45	45	NA																			
12		M	30	15	30	45	30	60	60	60	M	NA																		
13		15	15	15	30	15	30	H	H	H	1.5	1.5	M																	
14		30	15	15	45	15	15	45	45	45	3	30	9	NA																
15		M	M	M	60	30	30	75	105	105	M	30	15	9	NA															
16		120	45	90	45	30	30	60	60	60	15	60	M	9	60	60														
17		M	M	15	45	30	30	60	60	60	M	60	15	9	NA	NA	NA													
18		60	45	60	60	30	30	60	60	75	15	60	15	9	NA	NA	15	M												
19		60	45	60	60	30	30	60	60	60	15	60	15	9	NA	NA	15	M	M											
20		60	45	60	60	30	30	60	60	60	15	60	15	15	NA	NA	15	9	7.5	M										
21		60	45	60	60	30	30	60	60	60	15	60	15	7.5	NA	NA	15	M	M	M	M									
22		60	45	60	60	30	30	60	60	60	15	60	15	9	NA	NA	15	7.5	7.5	4.5	M	M								
23		60	45	60	60	30	30	60	60	60	15	60	15	4.5	NA	NA	15	M	M	4.5	M	M	M							
24		60	45	60	60	30	30	60	60	60	15	60	15	9	NA	NA	15	M	M	4.5	M	M	M	M						
25		60	45	60	60	30	30	60	60	60	15	60	15	M	NA	NA	15	4.5	4.5	4.5	3	4.5	3	3	M					
26		60	45	60	60	30	30	60	60	60	3	60	15	M	NA	NA	4.5	4.5	4.5	4.5	M	M	M	3	M	NA				
27		M	45	60	60	30	30	75	75	105	M	60	15	9	NA	NA	M	15	15	15	15	15	15	15	15	4.5	NA			
28		75	45	60	60	30	30	60	60	75	30	60	15	15	NA	NA	15	15	15	7.5	15	15	15	15	15	7.5	15	M		
29		NA	45	60	60	30	30	60	60	60	3	60	15	M	NA	NA	7.5	15	9	15	15	15	15	15	9	M	7.5	15	M	
30		45	M	M	15	M	M	60	60	60	3	15	15	M	NA	NA	M	M	M	M	M	M	M	M	M	M	M	M	M	M

OFF SITE FACILITIES PROCESS UNIT

Notes :

Fig.LPP 14 highlights the recommended safety distances between equipment associated with refinery, chemical , and petrochemical plants.

This exhibit should be read in conjuction with national and local codes and regulations . Exceptions to this exhibit should be by client specification only .

Dimensions shown are to the face of equipment and are minimum .

Fixed fire water sprays should be provided over equipment that handles flammable materials and operates at temperatures greater than 500° F (260° C) and over equipment that handles light hydrocarbons with a vapor pressure greater than 500 psi (35 kg/cm) that is located directly beneath air-cooled exchangers .

15. <u>Equipment Elevations</u>

Equipment should generally be elevated a minimum height from grade to suit process, operational , and maintenance requirements. Horizontal drums, shell and tube exchangers, and furnaces must be supported from grade by concrete piers. Vertical vessels (e.g. towers and reactors with attached skirts) and base plate equipment with pumps should be supported at grade by concrete foundations.

a. English Measurement

Large vacuum or crude towers with swaged bottom sections and compressors that are to be elevated for operational needs must be supported from concrete structures. Equipment that must be elevated for process requirements (e.g. shell and tube overhead condensers) must be supported in structures. When practical , air coolers should also be supported from overhead pipe racks. Equipment elevations must be in accordance with

Fig.LPP 15

Equipment Elevations

Item	**Support Reference**	**Open Installation**		**Enclosed Installation**	
		Ft	**Mm**	**Ft**	**mm**
a. Process Units and Utility Plants					
Grade Paving floors	High point	100’	100,000	100’6"	100, 150
	Low Point	99’6"	99,850	100’2"	100, 050
Vertical Vessels	Bottom of base ring or legs POS	100'6"	100,150	101'	100, 300
Tankage	Bottom POS	101'	100,300	101'6"	100, 450
Horizontal Vessels	Bottom of Saddles & EL	As required for NPSH or for operation and maintenance			
Pumps, blowers, package Units	Bottom of baseplate	100'6"	100,150	101'	100, 300
Independent lubricated Compressors	Bottom of baseplate & shaft	As required for lube oil return piping or Surface condensers			

Motor-driven reciprocating compressors	Bottom of baseplate & shaft	As required for clearance at pulsation bolts and piping			
Furnaces, wall or roof- fired	Bottom of floor plate POS	104'	101,200	NA	NA
Furnaces, floor-fired	Bottom of floor plate POS	108'	102,400	NA	NA
Vertical reboilers	Bottom of lugs POS	As required to suit structure or related tower			
Pipe racks	Top of Steel	As required to suit clearances for Operation and maintenance access			
b. Off Site					
Grade Paving floors	High Point	9"	230	1'3"	380
	Low Point	3"	5	9"	230
Vertical vessels	Bottom of base ring or legs POS	1' 3"	380	1' 9"	530
Storage Tanks	Top of berm or bottom of tank POS	1'	300	NA	NA
Horizontal vessels	Bottom of saddles & EL	As required for NPSH or for operation and maintenance			
Pumps, blowers, Packaged Unit	Bottom of baseplate	1' 3"	380	1'9"	530
Cooling towers , clarifiers clear walls	NA	As required		NA	NA
Grade pipe sleepers	Top of steel	1'	300	NA	NA

16.Maintenance

Adequate clearance must be provided adjacent to or around equipment and controls that require in-place servicing or that requires removal from their fixed operational location for repair.

If equipment is located within shelters, suitable facilities (e.g. trolley beams or traveling cranes) must be provided to lift and relocate the heaviest items. Drop areas must exist within shelters that use fixed handling facilities. There should also be drop areas for vertical equipment that must be lowered to grade. There must be adequate area at all shell and tube exchangers for rodding or tube bundle removal and at furnaces for coil removal. Fig.LPP 16 highlights some of the principle maintenance activities and handling devices associated with a conventional operating plant.

17.Plant Operation

There must be clear access at grade and at elevated platforms so that operation of the plant can proceed in a safe and unrestricted manner. Valves and instruments are to be placed so that they can be operated or viewed but do not impede access at grade and elevated walkways.

Operating valves that cannot conveniently be located below a centerline elevation of 6 ft 9 in (2.050 mm) from grade or platform must have chain operators, extension stems, or motor operators. Except for battery limit valves, all unit isolation valves must be located at grade Fig.LPP 17 highlights the minimum requirements for operator access to controls.

18. <u>Above-Ground Piping</u>

With the exception of pipeline pumping stations, sewers, and most cooling water systems, piping is generally run above grade in process plants. When located below ground, process piping that has protective heating or that requires inspection and servicing should be located in trenches.

In process units and utility plants, piping to equipment must run overhead to meet operator and maintenance clearances. Short runs of piping (e.g. pump suctions) , however, may run at grade, where they do not obstruct access ways. Piping in such off-site areas as tank farms must run approximately 18 in (450 mm) above grade and must provide adequate access to controls and maintenance areas by walk-over stile off site pipe racks must be located adjacent to storage tank dikes. Within diked areas, piping must run by the most direct route unless limited by flexibility and tank settlement. Piping serving a tank or tanks in a common area must not run through adjoining diked areas.

All insulated piping that passes through dike and all piping passing under roads or railroads must be enclosed in metal pipe sleeves. Uninsulated piping passing through dikes should be coated and wrapped but not sleeved. Piping systems must facilitate the removal of equipment without removing the associated piping and controls.

Piping systems are to be arranged with sufficient flexibility to reduce any excessive stresses and, where possible, to accommodate expansion without using expansion bellows. Line spacing should be based on anticipated line movements under regular operating conditions. The top of stacks and continuously operating that discharge hazardous vapors must be positioned at least 10 ft (3,000 mm) above any platform within horizontal radius of 70 ft (21,000 mm) from the vents or stack. Intermittent vents that discharge hazardous vapors into the atmosphere are to be located a minimum of 10 ft (3,000 mm) above any platform within horizontal radius of 35 ft (10,500 mm) from the vent.

The vertical distance may be reduced for vents and stacks discharging into the atmosphere by the same distance that a platform is outside the safety area from the vent or stack, as illustrated in Fig.LPP 18

Nonhazardous vapors (e.g. air or steam) must be directed away from personnel.

Fig.LPP 16

Maintenance Requirements

Item	**Activity**	**Handling Device**
Vertical Vessel	Maintenance access cover removal Relief and control valve removal Catalyst loading and unloading Vessel internal removal	Maintenance access davit Top head davit Mobile Crane Top head davit or mobile crane
Exchangers	Cover removal (horizontal)	Hoist trestle with load up to 2.000 lb (900 kg) or mobile crane
	Bottom cover removal (vertical)	Hitch points
	Top cover removal (vertical)	Mobile crane
	Bundle removal (horizontal)	Mobile crane and extractor
	Bundle removal (vertical	Mobile crane
	Rodding	Manual
	Air cooler tube removal	Mobile crane
	Plate removal (plate exchanger)	Manual
Pumps compressors	Motor or largest component removal (housed)	Trolley beam or traveling crane
	Motor or largest component removal (open installation)	Mobile crane or hoist trestle with load up to 2.000 lb (900 kg)
Furnaces Miscellaneous	Vertical pumps Coil removal	Mobile crane Mobile crane
	Filter removal	Manual or hoist trestle
	Strainer removal	Manual
	Relief valves, 4 to 6 in and larger	Davits , hitch points, or

		mobile crane
	Blinds, blanks figure 85 and valves more than 300 lb (135 kg)	Hoist trestle
	Small components, 300 lb (135 kg) and less	Manual or hoist trestle

Fig.LPP 17

Operator Access to Controls

Item	Platform or Grade	Fixed Ladder
Maintenance access	Yes	No
Level controls	Yes	No
Motor operated valves	Yes	No
Sample connections	Yes	No
Blinds and figure 85	Yes	No
Observation doors	Yes	No
Relief valve	Yes	No
Control valves	Yes	No
Battery limit valves	Yes	No
Valves , 3 in and larger	Yes	No
Hand holes	Yes	Yes
Valves, smaller than 3 in	Yes	Yes
Level gauges	Yes	Yes
Pressure instruments	Yes	Yes
Temperature Instruments	Yes	Yes
Vessel nozzles	No	No
Check valves	No	No
Header block valves	No	No
Orifice flanges	No	No

19. Plot Plans

The plot plan is one of the key documents produced during the engineering phase in any processing facility. It is used to locate equipment and supporting infrastructure and to establish the sequence of major engineering and construction activities. Plot plans are used by almost every engineering and construction activities. Plot plans are used by almost every engineering group within a project task force from estimating and scheduling through construction. The plot plan is developed by the plant layout designer, usually at the proposal stage of the project, and remains the responsibility of the designer throughout construction . Similar process units engineered for two clients may look vastly different for various reasons, including available real estate, soil and climate conditions, and client philosophy on operation, maintenance, and safety. For these reasons, standardization of process unit plot plans is difficult. Nevertheless, as most operating facilities use common equipment (e.g. shell and tube heat exchangers, pressure vessels, pumps, and compressors) , it is possible to apply a few basic rules that suit most clients and processes and that enable the plant layout designer to approach the task of arranging the equipment and supporting facilities in an orderly manner.

20. The Plot Plan in the Process Unit

This chapter highlights the general requirements for process unit plot plan arrangement. It identifies the information required to locate operating equipment and supporting facilities to suit operator and maintenance access, constructability, process operation, safety, and cost-effective design.

21. Definition

The process unit plot plan is an arrangement drawing that highlights the equipment and supporting facilities (e.g. pipe racks and buildings). These are required for a given process integrated within a common battery limit area, usually designed for independent operation and shutdown. The final plot plan identifies all the components by designated numbers and shows, to scale, the basic shapes of the equipment and supporting facilities, locating them in both the vertical and the horizontal planes. Generally, the arrangement is shown in the plan with elevated views furnished only for clarity (e.g. in the vertically structured plant). Plot plans developed with three-dimensional CAD modeling have the advantage of producing multiple plans, elevations, and isometric views with no additional effort. The plot plan is used for the functions discussed in the following sections.

- **Piping Design -** The plot plan is used to produce equipment arrangement studies that facilitate the interconnection of above and below ground process and utility piping systems and to estimate piping material quantities.
- **Systems engineering –** The plot plan is used to facilitate hydraulic design, line sizing, and utility block flow requirements.
- **Scheduling –** The plot plan is used to schedule the orderly completion of

engineering activities.

- **Construction –** The plot plan is used to schedule he erection sequence of all plant equipment, which includes rigging studies for large lifts, constructability reviews, marshaling, and lay-down areas throughout the entire construction phase.
- **Estimating –** The plot plan is used to estimate he overall cost of the plant.
- **Client Use –** The plot plan is used for safety , operator, and maintenance reviews and to develop an as-built record of he plant arrangement.

22. Plot Plan Development

Developing a plot plan is not an exact science, because the arrangement of the plant must be set at the beginning of the project before all equipment requirements and configurations are finalized and before all of the mechanical problems associated with the design are solved. Plot plan arrangement is a reflection of the designer's ability to anticipate mechanical problems and provide he necessary access for operation and maintenance as well as the designer's general experience with plant layout requirements. The intended goad is to produce a safe, cost-effective operational plant, which will probably remain in use for at least 25 years. Therefore, it is important that any errors in arrangement be recognized and eliminated during he plot plan development phase of he project because they can be costly to correct once the plant is in operation.

Plot plans are generally developed in stages. From the initial concept to the fully dimensioned document at the construction issue stage.

The proposal plot plan , shown in Fig.LPP 19 is developed during the estimate phase of the project and is used to estimate bulk materials. It is also included in the proposal as a representation of the unit arrangement to the prospective client. The proposal plot plan is based on limited information and generally indicates only the principal items of equipment main supporting facilities, and overall dimensions.

After contract award, the proposal plot plan is updated to suit the latest information and is reviewed and approved by the client. This document becomes the basis for the plant layout phase of he project and is called the planning plot plant. A sample planning plot plan is shown in. Fig.LPP 20 On completion of the plant layout phase - when all the equipment has been sized and is in the best position to suit the project requirements and when all access roads, buildings and pipe racks have been located—the plot plan finally issued for construction. This is illustrated in Fig.LPP 21 as the construction plot plan. To develop a plot plan, the designer must assemble the information discussed in the following sections.

- **The Equipment List -** This document lists all the items of equipment and buildings by number and description to be included within the unit battery limits. A sample equipment list is given in Fig.LPP 22
- **The Process Flow Diagram –** The process flow diagram is one of the most important documents required by the designer to position equipment. It indicates flow rates, temperatures, and pressures and how the various pieces of equipment are interconnected. The process flow diagram generally does not show utility equipment (e.g., drives, surface condensers, and injection packages). These can be obtained from the equipment list. The process flow diagram does not always show the true representation of the equipment. A shell and tube exchanger shown as a single item could turn out to be two or more shells for a large load. Fig.LPP 23 shows a process flow diagram that incorporates the items in the sample equipment list.
- **The block flow diagram –** The block flow diagram shows all primary interconnecting lines between process units, utility plants, and storage facilities. Although not absolutely essential, it is a useful document for equipment location.
- **Process design data –** The process design data gives site information on a map or an overall existing plot plan. The existing plot plan, or site map, shows such geographic details as roads, railroads, rivers or seashore, land contours, and inhabited areas. It also indicates the location and extent of real estate available for the new facility or expansion. The process design data indicates weather conditions (e.g. average seasonal temperatures, rainfall

records, and prevailing winds). It also gives the plant elevation datum and reference coordinates for plant location.

- **Equipment sizes –** At this phase of he project, the equipment sizes for the plant are furnished by he supporting groups on the basis of preliminary information and cover such general items as floor space requirements (e.g. for a pump of known size) or a shell and tube exchanger ith only the tube diameter and length given. As the project progresses, equipment configurations and sizes become firm and the plot plan is updated accordingly. Fig.LPP 24 lists sample information that must be supplied.
- **Materials of Construction -** A materials specialist marks up a process flow diagram identifying special or critical piping materials (e.g. alloy and large heavy wall piping). The diagram assists the plant layout designer in optimizing equipment locations to suit the most economic piping runs.

Fig.LPP 22

Sample Equipment List

Item	Description	Item	Description
Furnaces 101-F	Charge furnace	Towers	
Exchangers		101-T	Stripper
101-E	Stripper reboiler	Reactors	
102-E	Stripper feed/effluent exchanger	101-R	Reactor
103-E	Stripper overhead trim condenser	Drums	
104-E	Reactor effluent trim cooler	101-D	Feed surge drum
105-E	Stripper overhead condenser	102-D	Recycle compressor Suction drum
106-E	Reactor effluent cooler	103-D	Make-up compressor suction drum
107-E/A to H	Combined feed exchangers	104-D	Water injection drum
108-E	Surface condenser	105-D	Stripper reflux drum
109-E	Product cooler	Compressors	

Pumps		101-C	Recycle compressor
101-PA	Charge pump	102-CA	Make-up compressor
101-PB	Spare charge pump	102-CB	Spare make-u compressor
102-P	Water injection pump	Miscellaneous	
103-PA	Stripper bottoms pump	101-CL1	Lube oil console
103-PB	Spare stripper bottoms pump	101-L	Corrosion inhibitor injection system
104-PA	Stripper reflux pump	101-H	Compressor house
104-PB	Spare stripper reflux pump	101-HL	Overhead traveling crane
105-PA	Condensate pump		
105-PB	Spare condensate pump		

23. Types Of Plot Plan

Plot plans are often referred to by their process (e.g. , an ammonia plant or hydrotreater unit) rather than by the type of configuration of the equipment layout. In terms of equipment arrangement, process unit plot plans can basically be divided into two configurations: the grade mounted horizontal inline arrangement seen in most refinery facilities, and the structure mounted vertical arrangement found in many chemical plants.

24. The Grade-Mounted Horizontal Inline Arrangement

The horizontal inline unit is usually located within a rectangular area, with equipment placed on either side of a central pipe rack serviced by auxiliary roads. The principle advantage of this arrangement is that the equipment is generally located at grade, which makes this type of plant easier to construct and more accessible for maintenance and operation. The disadvantages are the amount of real estate required and the long runs of cabling, utility, feed, and product piping required to service the unit. Fig.LPP 25 shows a typical horizontal inline plot plan arrangement.

Fig.LPP 24

Floor Space Size

Exchangers

Item	**Bundle Diameter**	**Length**
101-E	36 in (915 mm)	20 ft (6.100 mm)
102-E	30 in (750 mm)	20 ft (6.100 mm)
103-E	30 in (750 mm)	20 ft (6.100 mm)
104-E	24 in (610 mm)	20 ft (6.100 mm)
105-E (A/C)	30 ft (9.150 mm)	40 ft (12.200 mm)

106-E (A/C)	30 ft (9.150 mm)	20 ft (6.100 mm)
107-E (8 shells)	36 in (915 mm)	24 ft (7.300 mm)
108-E	60 in (1.500 mm)	15 ft (4.600 mm)
109-E	30 in (750 mm)	20 ft (16.100 mm)
Pumps		
Item	**Length**	**Width**
101-Pa/b	5 ft (1.500 mm)	2 ft 6 in (750 mm)
102-P	2 ft 6 in(750 mm)	1 ft 3 in (380 mm)
103 Pa/b	4 ft 6 in (1370 mm)	2 ft (610 mm)
104 Pa/b	4 ft (1220 mm)	1 ft 6 in (450 mm)
105 Pa/b (vertical)	1 ft 6 in (450 mm)	1 ft 6 in (450 mm)

25. The Structure-Mounted Vertical Arrangement

The structure-mounted vertical arrangement has equipment located in a rectangular multilevel steel or concrete structure. The structure can be several bays long and either open-sided or fully enclosed, to suit either client performance or climate conditions. Piping and cabling usually enter and exit the structure at one level and gain access to each floor by chases or are supported from the outside members Operation usually gain access to each level by stairs or by elevator. Equipment maintenance is usually accomplished through the use of hitch points , trolley beams, or traveling cranes. An adequate area must be provided around each item along with a clear drop zone at grade for equipment removal. The structure is serviced by access roads.

The advantages of this type of arrangement are the small amount of real estate required for the plant and the ability to house the facility to suit process requirement or climate conditions. The disadvantages are in the operator and maintenance access and in the construction of the plant Fig.LPP 26 shows a typical structure – mounted vertical plot plan arrangement.

26. Equipment Location

Various requirements dictate the location of equipment and supporting facilities within the conventional operating plant, and many factors must considered when the designer is locating equipment. They are discussed in the following sections.

27. Economic Piping

The major portion of the piping within most process units is used to interconnect equipment and support controls between equipment. To minimize the cost of this bulk material, equipment should be located in process sequenced and close enough to suit safety needs, access requirements, and piping flexibility. The sequential interconnection of the unit is shown on the process flow diagram. The first step is to identify the alloy or heavy wall piping. The diagram should then be subdivided into smaller groups of process related equipment. These groups should contain an assembly of related equipment and controls that function as a subsystem within the main process unit. The components within the subsystem should be arranged to suit the most economic piping runs, and the whole assembly should be positioned within the plot area to provide the most economic interconnection between related process subsystemsFig.LPP 27 shows a process flow diagram divided into subsystems, an arrangement of a subsystem, and the interconnection of a group of subsystems.

28.Process Requirements

Equipment often must be located in a specific position to support the plant's process operation (e.g. for pressure drop, line pocketing, and gravity feed). The plant layout designer must be familiar with the process because the process flow diagram rarely indicates this information. It is recommended that the designer discuss these requirements with the process engineer before processing with the plant arrangement. Fig.LPP 28 shows the effect of an arrangement with a gravity feed process requirement.

29.Common Operation

Equipment that requires continuous operator attention or shares common utility and maintenance facilities should be located in the same area. For example, compressors generally require 24-hour operator attention. Compressors with condensing steam turbine drives often share the same surface condenser and are located in a compressor house using a common fixed handling facility (e.g. an overhead traveling crane). Although this arrangement is often more expensive in terms of piping components , the use of common facilities (e.g. the surface condenser, building, and equipment handling facilities) makes up the difference in cost Fig.LPP 29 shows a typical compressor area arrangement.

30.Real Estate Availability

Generally, most new process units are built within an existing facility in which a piece of land is dedicated to the new expansion. Older process units, which have undergone many expansions, often leave a less than desirable piece of real estate for the next new facility. This can be a problem for inline horizontal arrangements but is less so far vertical structure arrangements, which require less ground space. When an inline arrangement is constructed, it is recommended that parts of the unit be located in elevated structures with related equipment located adjacent to it if the process permits. For an already elevated plant, adjustments can be made in the overall size of the structure and extra floors can be added. Care must be taken to adjust usual plant configurations to suit minimum space requirements so that the plant is not too difficult to maintain. Fig.LPP 30 shows an arrangement before and after it has been adjusted to suit minimum space requirements.

31.Equipment Sizes

Ideally, all the different types of equipment within the process unit would be the same size. This rarely occurs, however, and the plant layout designer often struggles to place a large, cumbersome piece of equipment into an area while retaining the aesthetics of the unit. Generally, most plants are dominated by conventional rectangular and circular equipment of a reasonable size. Some processes, however, require much larger and more awkwardly shaped items (e.g., an orthoflow converter and expander train in a fluid catalytic cracking unit, as displaced in, Fig.LPP 31 a reformer furnace in an ammonia unit, or a waste heat recovery system in a large cogeneration plant). In these situations, he designer should place these items first and plan the remainder of the unit around them.

Whether the planned plant is an inline arrangement or housed in a structure, the plant layout designer must make provisions for operator and maintenance access. The designer must review the items of equipment that are included in the process and plan for their operation and maintenance requirements. For example, towers must be located in a position to allow for the removal of internals, reactors require space for catalyst loading and unloading shell and tube exchangers require space for bundle removal, and rotating equipment needs space for drive and casing removal.

All these aspects of the equipment design add to the floor space requirements of the plant. Equipment that requires servicing during regular operation or planned shutdown periods should be accessible from the auxiliary roads or internal access ways. From the project specification , the plant layout designer should determine operator access requirements and the devices to be used for servicing before proceeding with the plant arrangement. Fig.LPP 32 shows typical access requirements in a vertical arrangement, and Fig.LPP 33 displays an inline arrangement.

32. Underground Facilities

There are a variety of underground facilities that could affect the positioning of equipment. Depending on soil conditions, the foundations for the equipment are either piled or spread footings. Spread footing foundations require more space than piled applications, and care should be taken to locate equipment so that enough space exists between equipment for the foundations of larger items. In cases, equipment can be supported don a common foundation. Depending on the project specification, instrument and electrical cabling can be located above or below grade. If located below grade, adequate space should be designated during the plot plan development stage. Underground piping is another factor that the designer must consider when locating equipment. Most process units are serviced by an underground oily water sewer, storm sewer, and fire water system and a chemical drainage system if required. In addition , the unit cooling system could be positioned below ground. All of these facilities require plot space, and it is recommended that the plant layout designer investigate what facilities are to be positioned below ground before proceeding with the equipment arrangement. Fig.LPP 34 shows a typical elevation through a unit below ground.

33. Climate Conditions

Weather conditions could influence the location of equipment. In a severely cold climate, equipment should be housed; this can be done by encasing the whole unit, as depicted in Fig.LPP 35 , or by individually housing groups of equipment (e.g. compressors or pumps), as illustrated in Fig.LPP 36 For individual housing, consideration must be given to locating equipment out of process sequence to minimize cost.

The wind can influence the location of such equipment as furnaces, compressors, control houses, cooling towers, and stacks. Furnaces or other fired equipment should be located so as not to allow flammable vapors to constantly drift. Smoke from stacks or vapors from cooling towers should not be in the direct path of main operating areas (e.g. compressor houses, control rooms, and structures).

34. Pipe Racks

Generally , most inline plant arrangements are furnished with a central pipe rack system that acts as the main artery of the unit supporting process interconnection, feeds, product and utility piping, instrument and electrical cables, and sometimes, air coolers and drums. Usually, the pipe rack is made of structural steel, either single level or multilevel, to suit the width and capacity of the unit it is serving. The pipe rack bays are usually spaced at 20 ft (6.000 mm) centers. The width is determined by such factors as the quantity o f piping and cabling to be carried on the main run of the pipe rack (with an allowance for future expansion), the equipment and access way located beneath the pipe rack, or the equipment (if any) supported above the pipe rack. The layout that results in the most economical design should be chosen.

At the estimate stage, when most plot plans are developed, the pipe rack width is specified on the basis of limited information; process flow diagrams usually are not available to accurately work out the exact requirements. Using the process flow diagram, the designer can prepare a line routing diagram on a print of the preliminary plot plan, similar to the instructions given in Pipe Rack This establishes the main process lines supported in the pipe rack for equipment interconnection, feed and production. An allowance of 20% of the main lines should be added to the total for unknowns. The pipe rack width can be adequately sized on the basis of approximate line sizing, utility piping, and insulation requirements by the process system engineer; cable tray requirements by the electrical and instrument engineers and a 20% future piping allowance. Most typical units require a two level pipe rack with a width of 20 ft (6,000 mm) to 40 ft (12,000 mm). If the total requirements exceed 80 ft (24,000 mm), an extra level should be introduced.

After establishing the pipe rack width to suit the piping and cable requirements , the designer must check the design for the accommodation of air cooler support, if specified, and pumps and access ways beneath the piper rack. The air cooler is specified by tube bundle length and is established at the estimate stage of the project. It can overhang the rack width equally on either side. An air cooler with a 40-ft (12,000 mm)tube bundle length can be adequately supported on a pipe rack that is 35 ft (10,500 mm) wide. Pumps may be located beneath pipe racks on either side of an access way that is 10 ft (3,000 mm) wide.

The bottom support elevation of the main pipe rack is dictated by the maintenance and piping clearance beneath the pipe rack with additional … spaced at 6 ft (1,800 mm) intervals. On projects with very large diameter piping, increasing this dimension to suit clearance requirements should be considered when pipe direction is changed. External clearances (e.g. over main roads or intersections with off-site pipe racks) need close attention.

Pipe rack configurations are dictated by the equipment layout, site conditions, client requirements, and plant economy. The ideal situation would be a straight-through arrangement, with process feeds and utilities entering one end of the unit and products and disposals existing the other end. The final layout of the pipe rack to meet the specific requirements of the project could result in a variety of configurations (e.g. a TL or U shape).

be accommodated by changes in elevation and are usually equally spaced about the midpoint of the main Pipe racks within vertically structured or housed facilities cannot be defined as easily as for inline arrangements, because the equipment is usually located on several levels. The vertical units are usually fed by conventional pipe racks at established elevations entering the structure at a designated area. Once inside the structure piping should be routed in an orderly manner according to economic, constructability, and support requirements .

35. Roads, Access Ways, and Paving

For maintenance and safety, the principal access to and from most process units is by auxiliary roads ideally, the unit battery limits should be positioned 50 ft (15.00 mm) from the centerline of the main plant roads. This allows adequate space for ditch drainage and firefighting facilities and avoids obstructing roads when such items as heat exchanger tube bundles are removed. Access ways or spur roads should be provided within the unit for access to items that require removal for off-site repair. Clearance according to project specification should be provided over roads and access ways for mobile equipment access. Most clients require that the equipment areas, the area beneath the pipe rack, and the areas around buildings be paved with concrete for housekeeping Fig.LPP 37 illustrates a typical process unit road and paving arrangement.

36. Buildings

Apart from buildings that house equipment (e.g. compressor houses), it is often necessary to position control houses , substations, analyzer houses, and operator shelters within the process unit battery limits. Administration buildings and warehouses are generally located away from process unit areas. Control houses and substations are usually located at the edge of the unit adjacent to a plant road, 50 ft (15.000 mm) from the operating equipment. As seen in Fig.LPP 38, analyzer houses and operator shelters should be located next to the equipment that they service.

37. Equipment Spacing

The previous sections have outlined the information required to locate equipment and the general content of the typical process unit. At this stage, the plant layout designer should prepare a sketch of the unit configuration and a line run to confirm that the equipment is positioned for the most favorable piping interconnection. The line run can be prepared by diagramming the principal process piping, as shown on the process flow diagram, onto a print of the plot plan arrangement sketch.

The final step in the plot plan arrangement is to space equipment and supporting facilities for operator and maintenance access, safety, piping flexibility and support, and platforming requirements. At this stage, the layout designer must rely on experience because the final information is not available for calculating exact distances between equipment or solving unforeseen mechanical problems. The spacing of the components within the unit is an important exercise –it finalizes real estate requirements for the facility and assists in the pricing of the plant. It is also used as the basis for the plant layout design.

Before spacing the equipment, the layout designer should review the sketched arrangement of the unit to confirm the exact requirements needed for safe and orderly operation of the plant. Consultation with process engineers is recommended to obtain general line sizing requirements for control spacing allowances. At this stage , the designer should be completely familiar with the project specification requirements for safety and for operator and maintenance access.

In a typical tower area, depicted in Fig.LPP 39, the tower and such related equipment as drums and heat exchangers are located adjacent to the main pipe rack, with maintenance access from the auxiliary road. The associated pumps are located beneath or adjacent to the pipe rack and are serviced by a central access way. Shell and tube heat exchangers can be located as single items or in pairs. If the process permits, they can be supported vertically or located in structures to meet gravity feed requirements. Vertical reboilers should be supported from their related towers. Multiple shell heat exchangers operating in series or in parallel may be stacked three high if size permits. Pumps beneath the pipe rack may, if size permits, be paired in each bay.

Compressors and their related equipment are usually located in one area for common operation and servicing adjacent to the main pipe rack and the auxiliary road. The suction drum for the machine should be positioned for flexibility in the piping and to accommodate orifice run requirements. If the compressor is driven by condensing turbine, a surface condenser and condensate pumps are required. If servicing one machine, the condenser may be located beneath the turbine. If services two or more, the condenser must be located adjacent to the machines it services. In both cases, space must be provided for condenser tube bundle removal.

The condensate pumps are usually vertical pumps and should be located as close to the condenser as possible to suit flexibility in the piping and vertical removal space. The lube oil console should be located as close to the compressor as possible with operator access on all sides the skid, with space to remove the cooler tube bundle, filters, and pumps. Interstage coolers, if needed, should be located adjacent to the compressor and suction drum. Adequate space should be provided. Fig.LPP 40 illustrates a typical compressor area arrangement. Air coolers, shown in Fig.LPP 41, are generally supported from the central pipe rack adjacent to their related equipment and are serviced by platforms at the header boxes and beneath the air coolers for motor maintenance. Care should be taken to position air coolers to allow flexibility for interconnecting piping. A poorly positioned overhead condenser could result in additional large overall diameter piping and expensive supports. Unless furnished with fixed fire water sprays, pumps containing hydrocarbons and operating higher than autoignition conditions should not be located directly beneath air coolers. Space should be available on the plot plan for maintenance access by mobile cranes for removal of air cooler tube bundles.

Furnaces should be located at a safe distance and upwind from unrelated equipment containing hydrocarbons. Steam drums or deaerators can be located as required for operation and maintenance. Reactors can be located closer to furnaces than other equipment containing hydrocarbons, as long as adequate space is provided for catalyst loading and unloading. Fig.LPP 42 shows a typical furnace area.

38.Sample Plot Plan Arrangement

The following illustrated examples show the various steps in arranging a naphtha hydrotreater unit and identify the process subsystems within the process flow diagram Fig.LPP 43 the initial arrangement sketch of the unit Fig.LPP 44, the line run check Fig.LPP 45, and the final plot plan arrangement Fig.LPP 46.

This chapter has highlighted some of the principal features involved in the arrangement of process equipment with regard to operation, , maintenance, constructability, safety, and economics. Subsequent chapters deal with the needs of each equipment item in more detail, thereby offering greater insight to proper equipment location on a plot plan.

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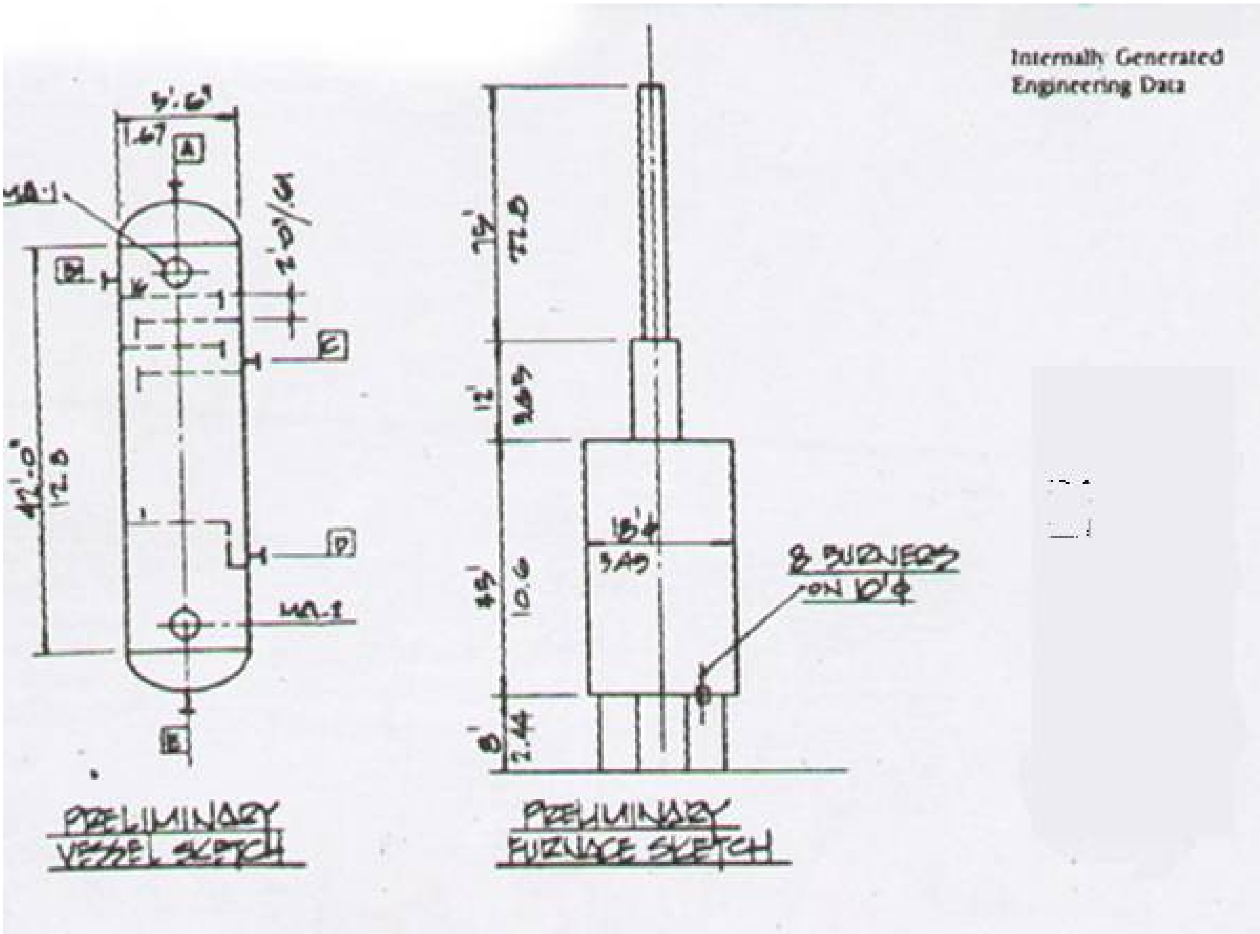

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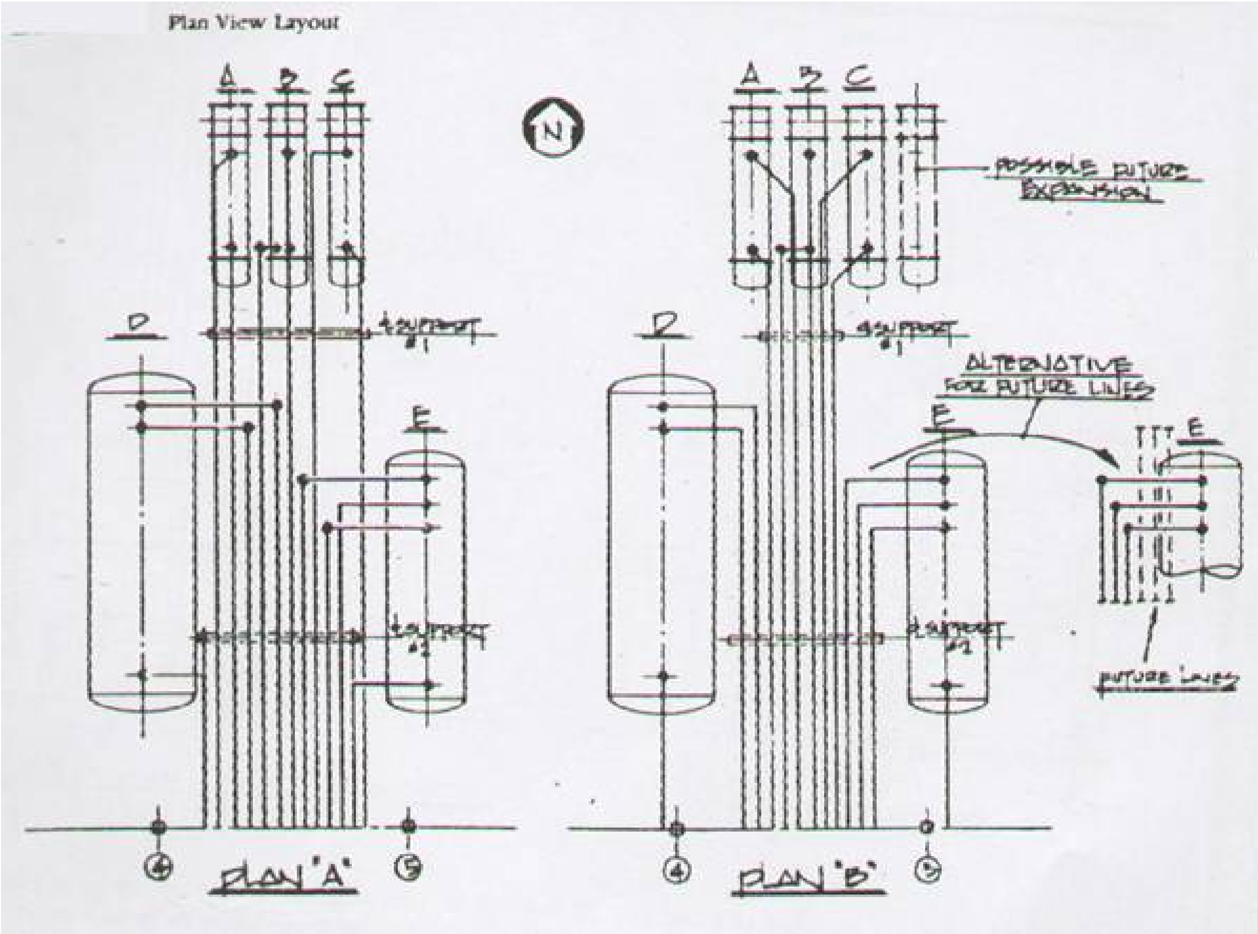

Plan View Layout
A
B
C
D
E
POSSIBLE FUTURE EXPANSION
ALTERNATIVE FOR FUTURE LINES
FUTURE LINES
PLAN 'A'
PLAN 'B'

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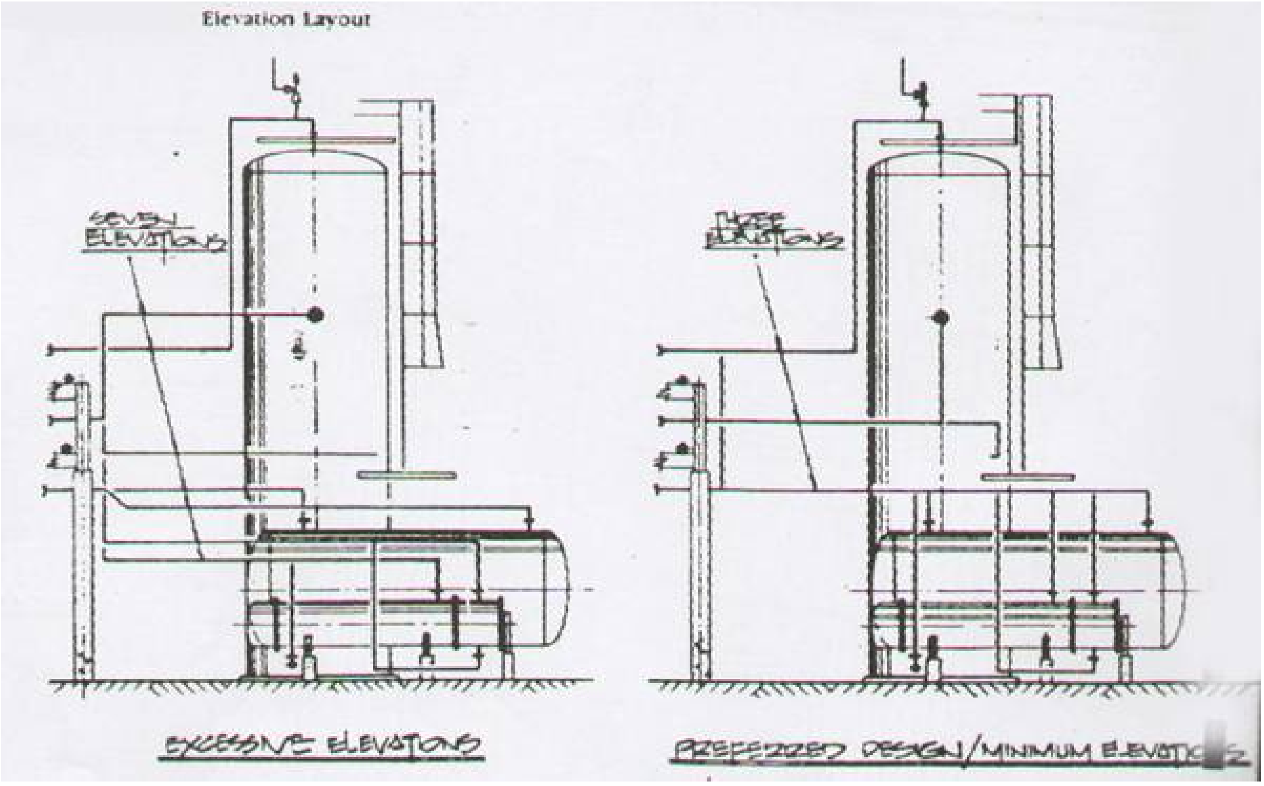

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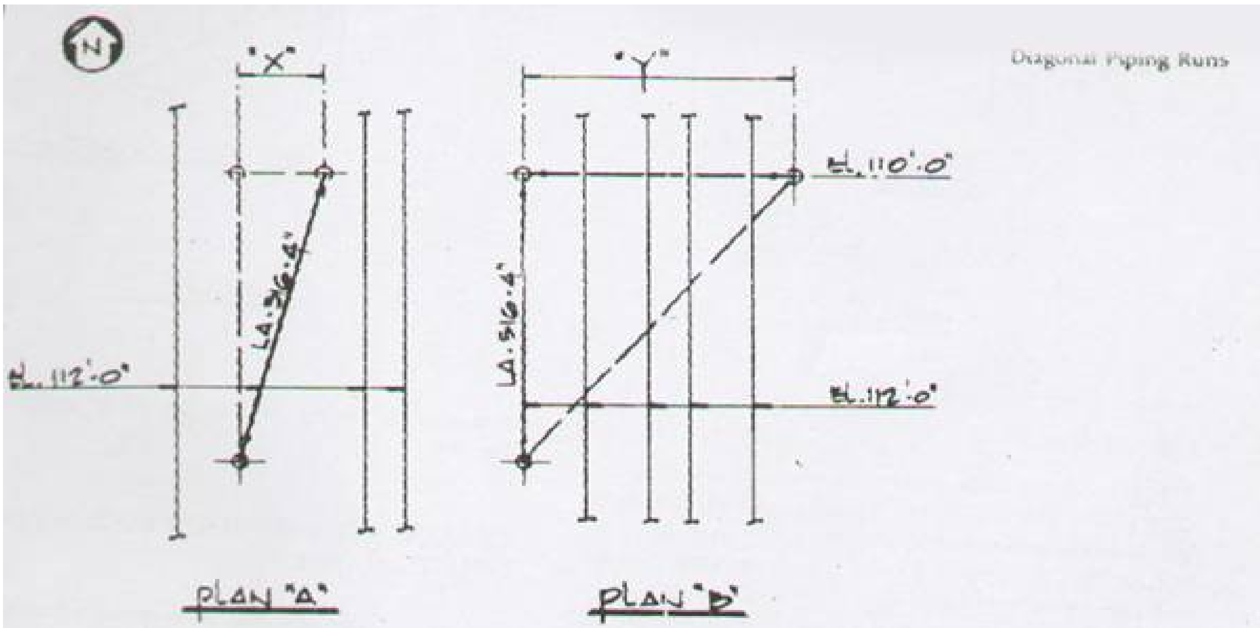

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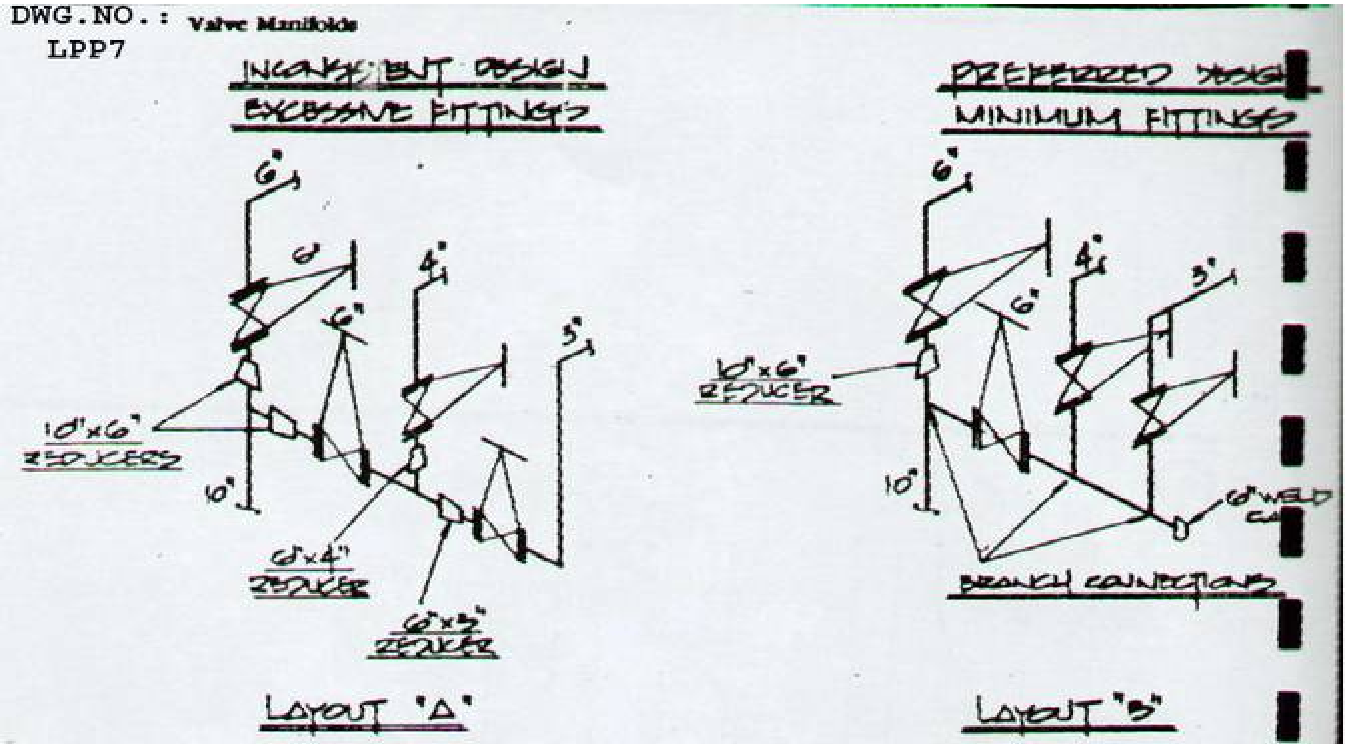
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PREFERRED DESIGN
MINIMUM FITTINGS
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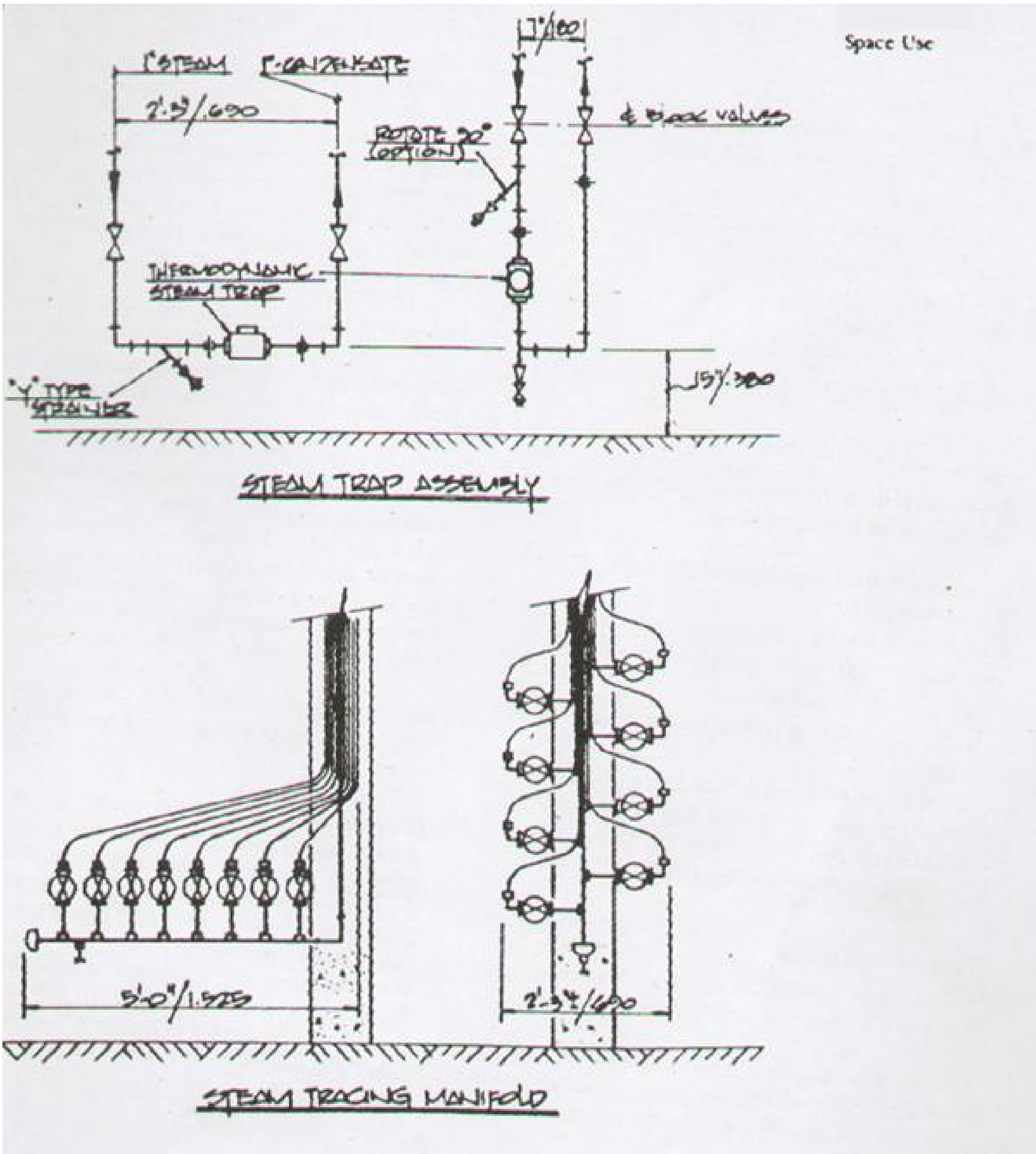
REDUCERS
6"x4"
REDUCER
6"x3"
REDUCER
10"x6"
REDUCER
BRANCH CONNECTIONS
LAYOUT "A"
LAYOUT "B"

DWG. NO. LPP 6


Space Use
ROTATE 90°
(OPTION)
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5'-0"/1.525
STEAM TRACING MANIFOLD

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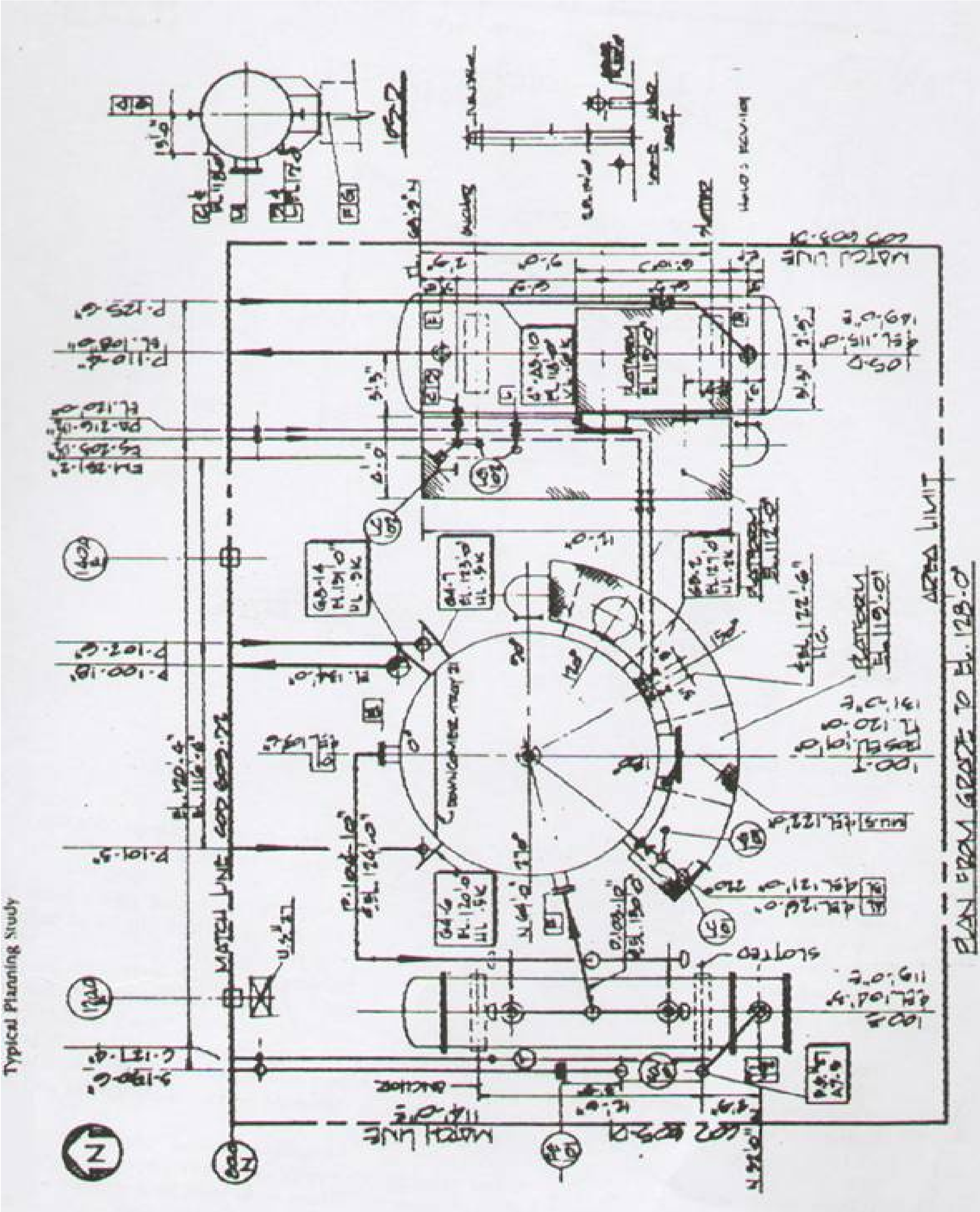
Typical Planning Study
PLAN FROM GRADE TO EL. 128'-0"
AREA LIMIT
MATCH LINE

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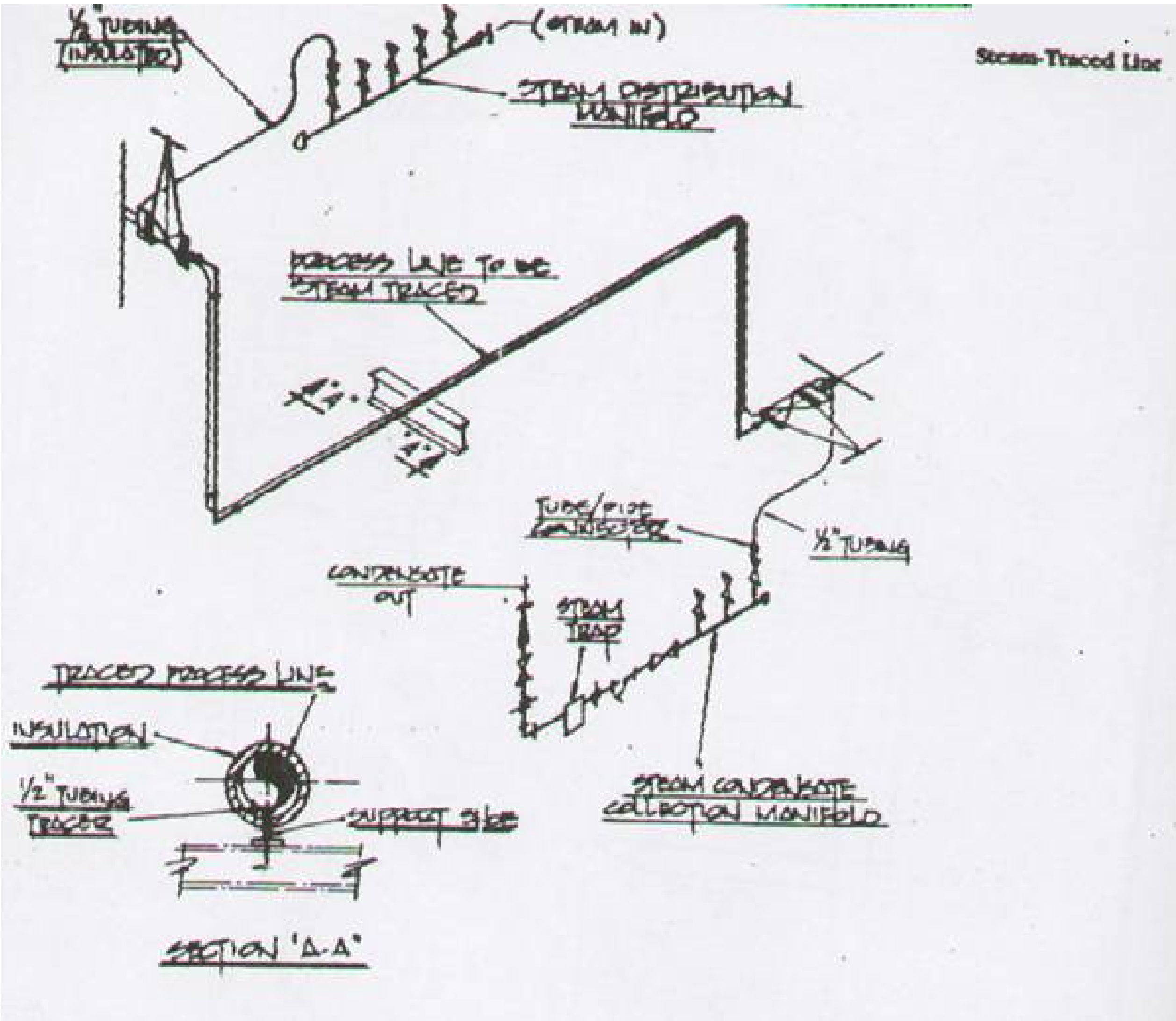

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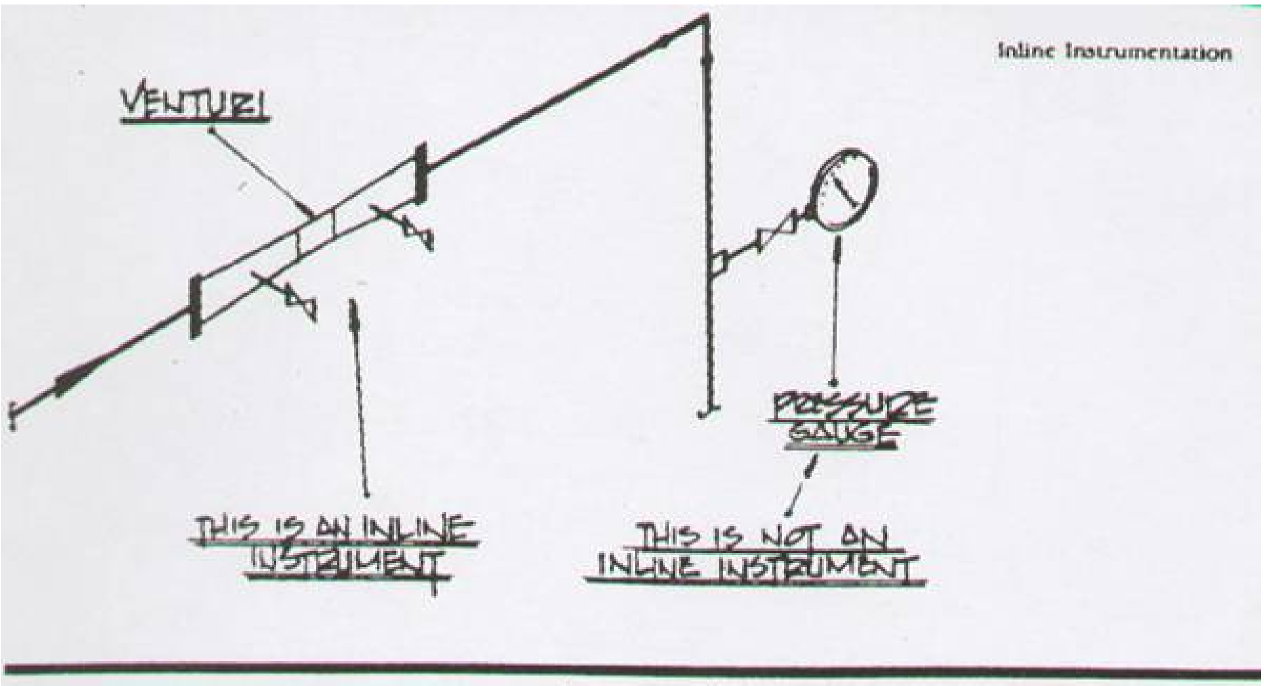


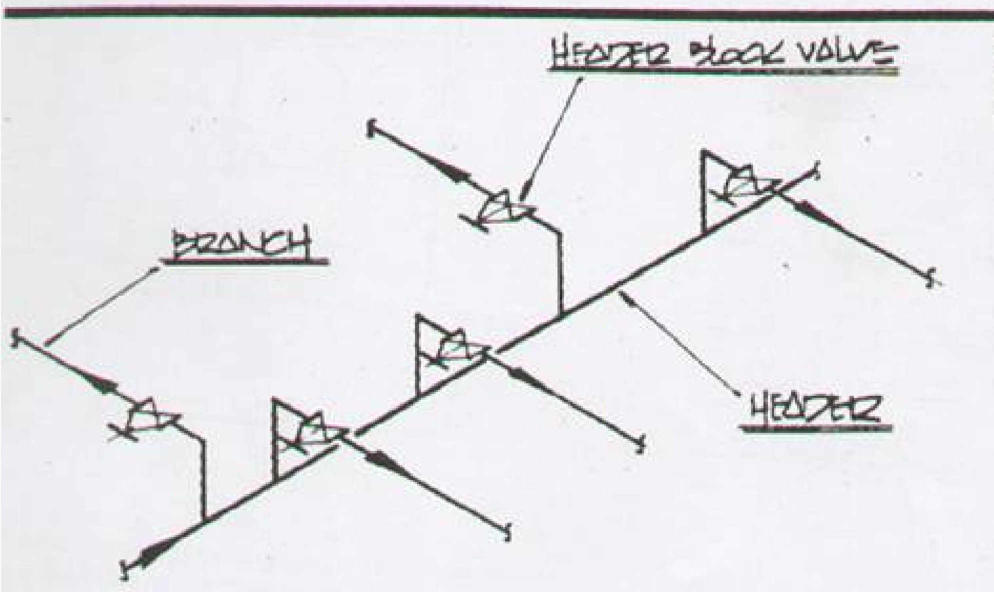
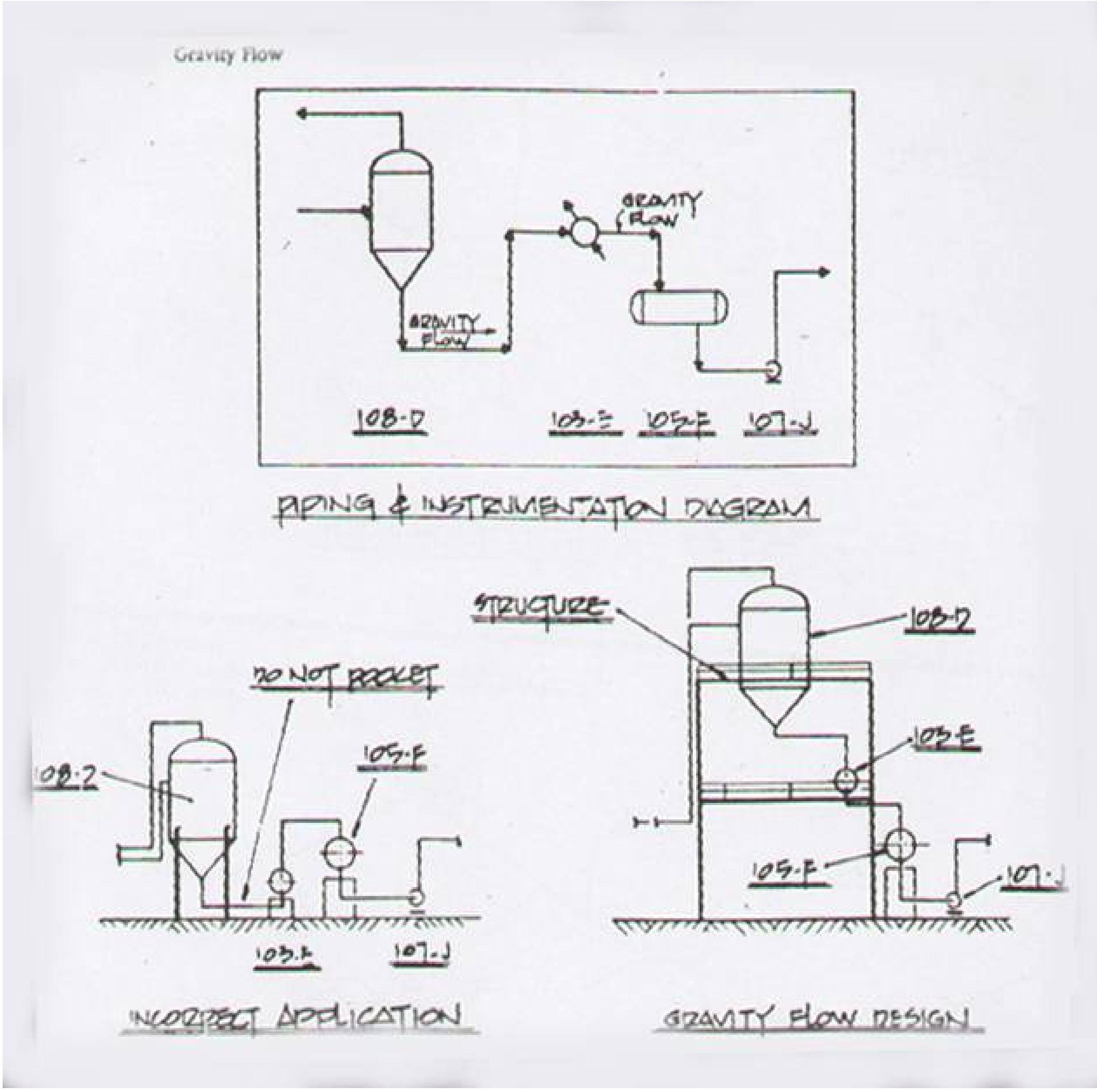
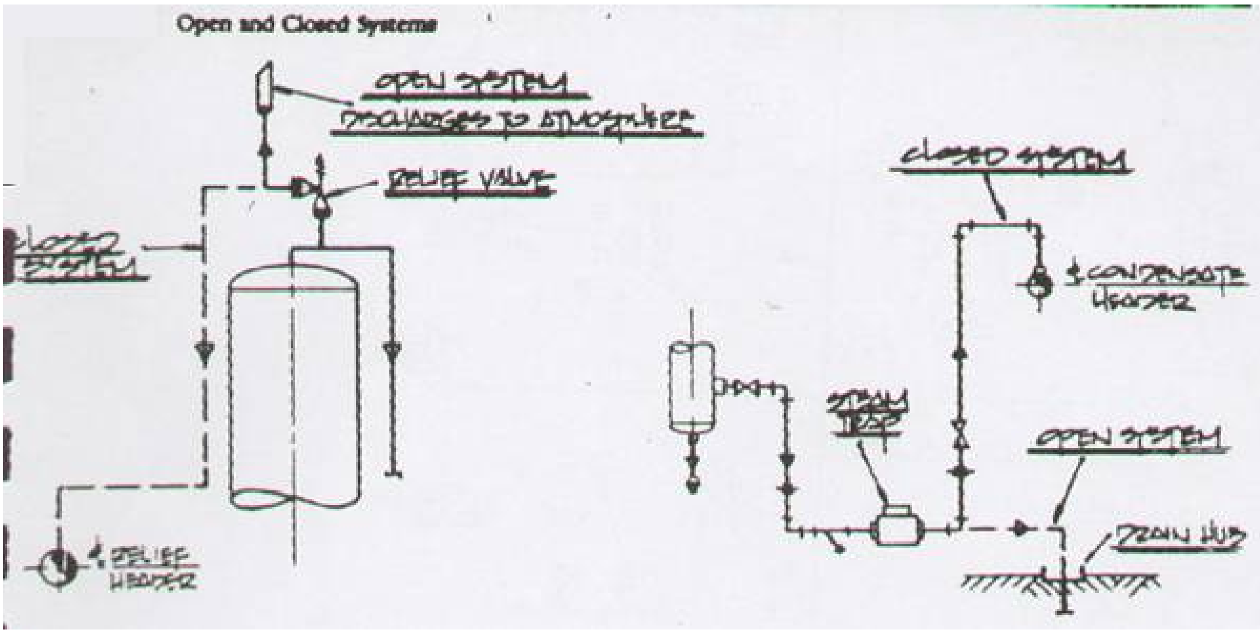


EXHIBIT 1-12
Header–Branch–Header
Block Valve

DWG. NO. LPP 11


Gravity Flow
GRAVITY FLOW
GRAVITY FLOW
108-D
103-E
105-F
107-J
PIPING & INSTRUMENTATION DIAGRAM
STRUCTURE
108-D
103-E
105-F
107-J
DO NOT POCKET
108-D
105-F
103-E
107-J
INCORRECT APPLICATION
GRAVITY FLOW DESIGN

DWG. NO. LPP 12



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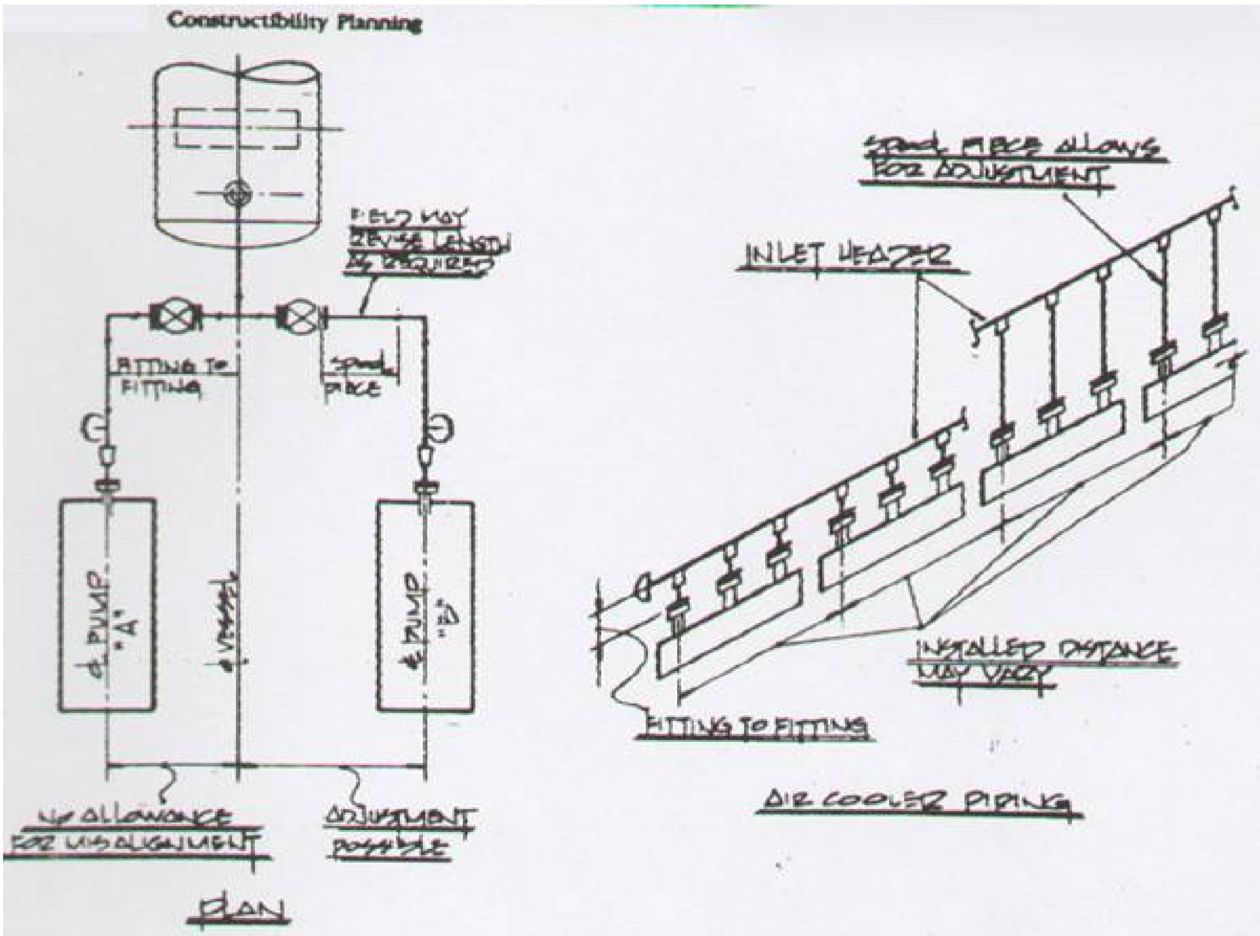

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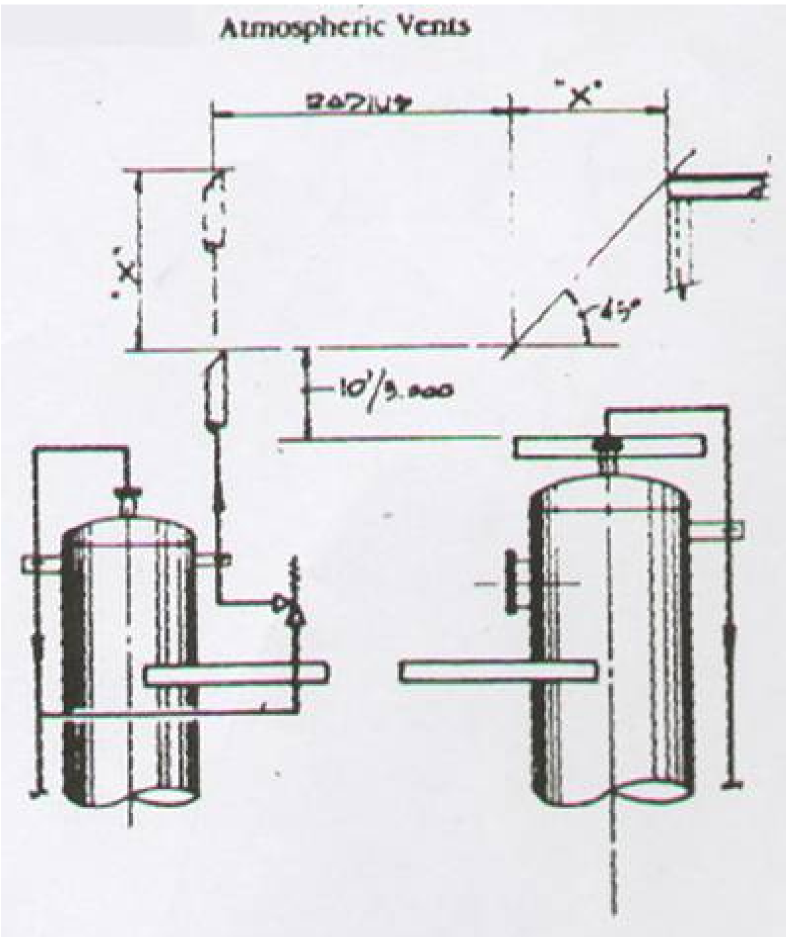
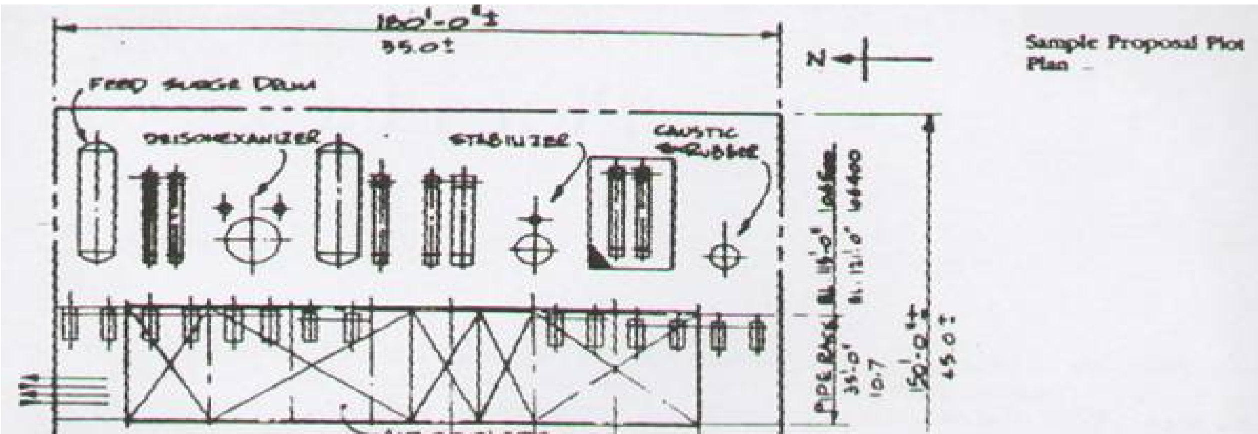
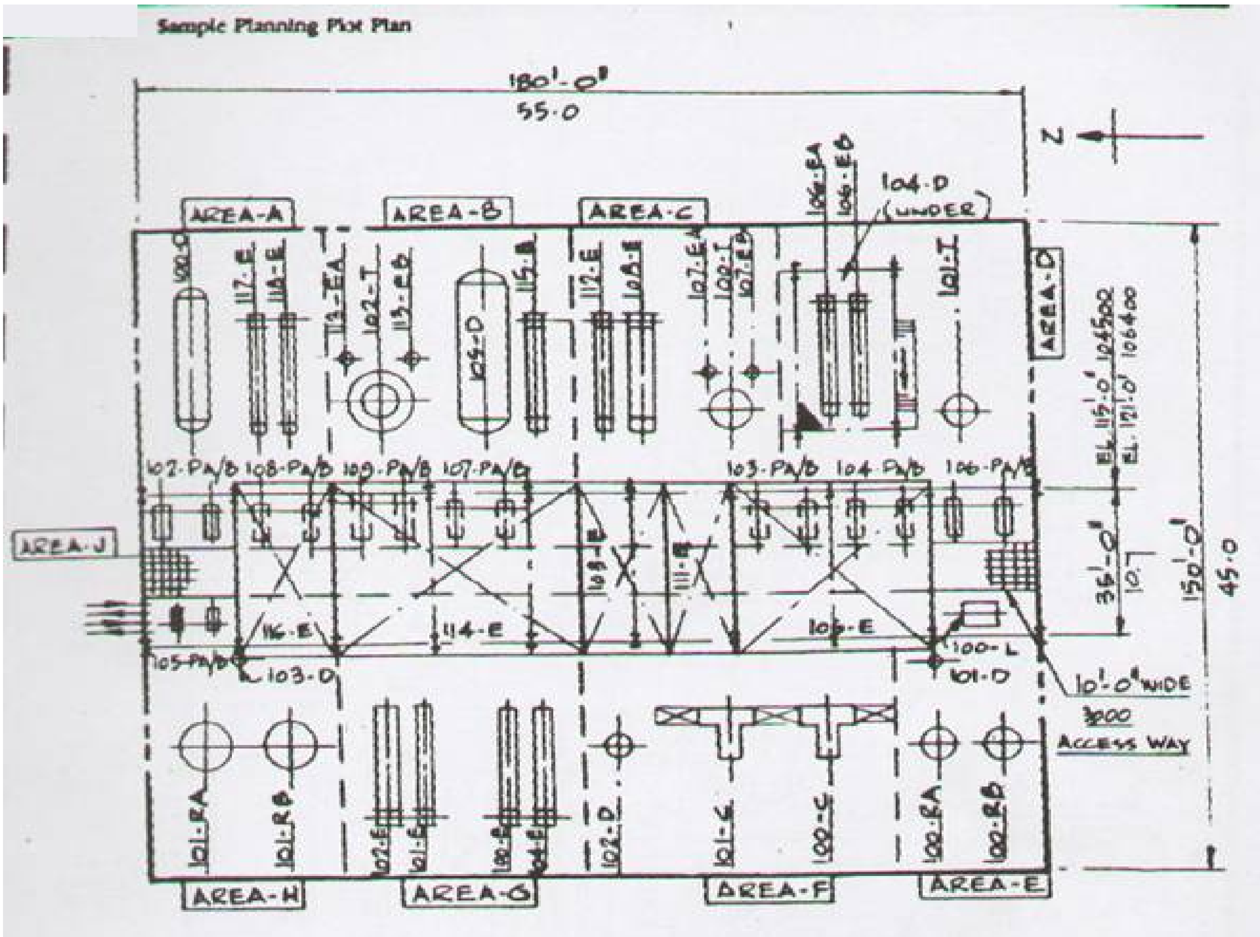


DWG. NO. LPP 19

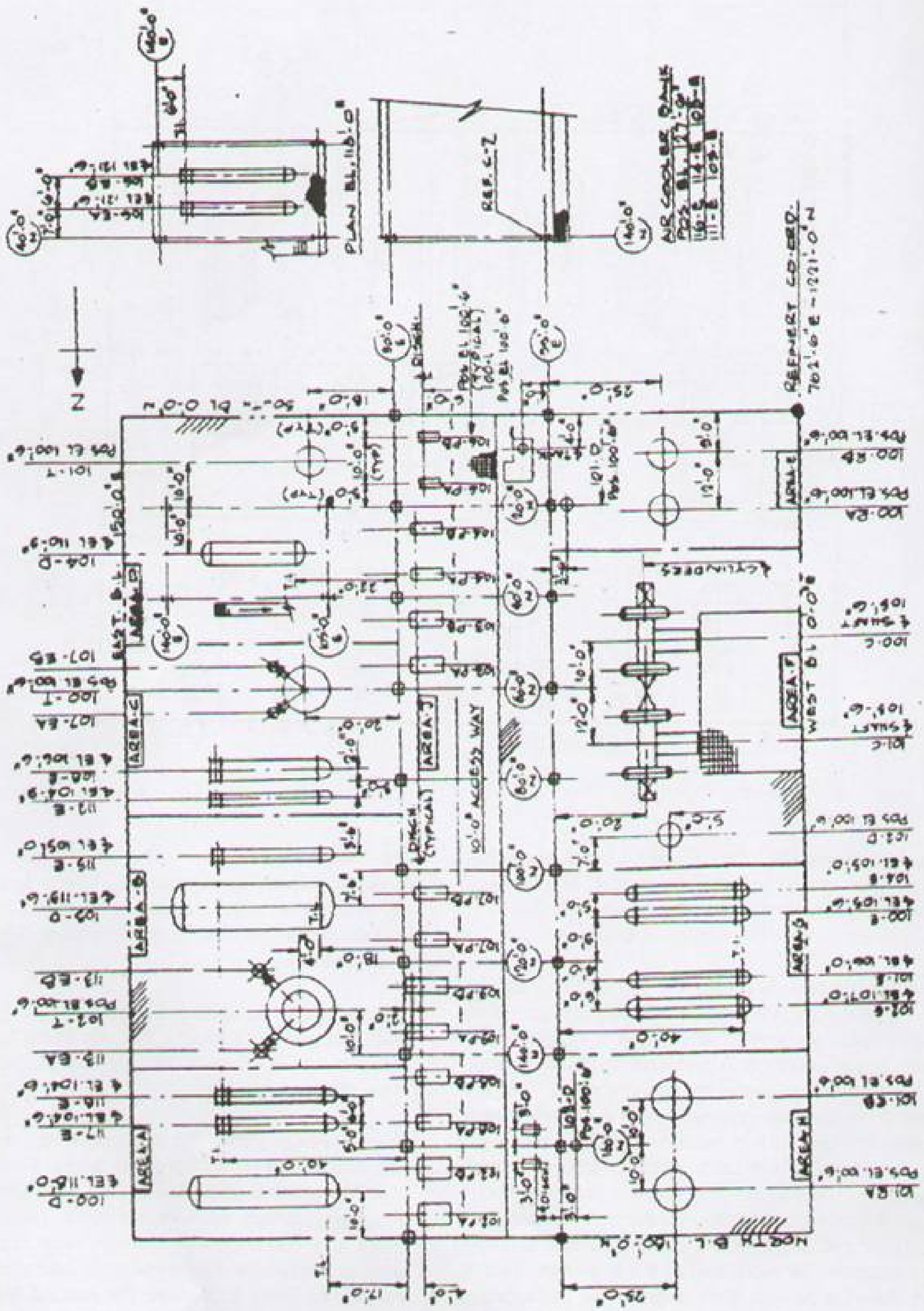


DWG. NO. LPP 20



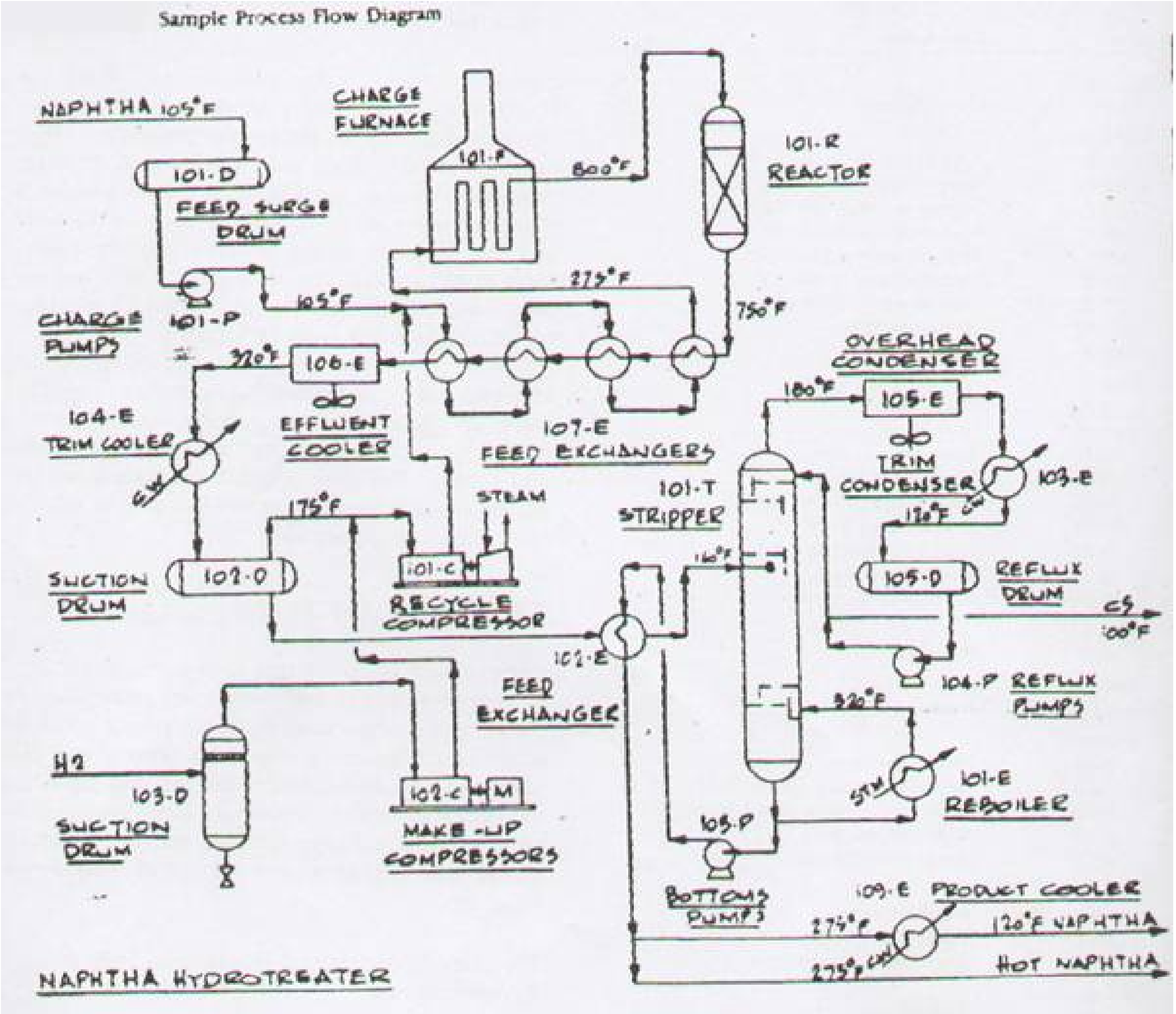
Sample Planning Plot Plan
180'-0"
55.0
N
AREA-A
AREA-B
AREA-C
AREA-D
AREA-E
AREA-F
AREA-G
AREA-H
AREA-J
104-D
(UNDER)
101-I
105-D
116-E
114-E
106-E
100-L
101-D
103-D
10'-0" WIDE
3000
ACCESS WAY
35'-0"
10.7
150'-0"
45.0
101-RA
101-RB
102-D
101-C
100-C
100-RA
100-RB

DWG. NO. LPP 21



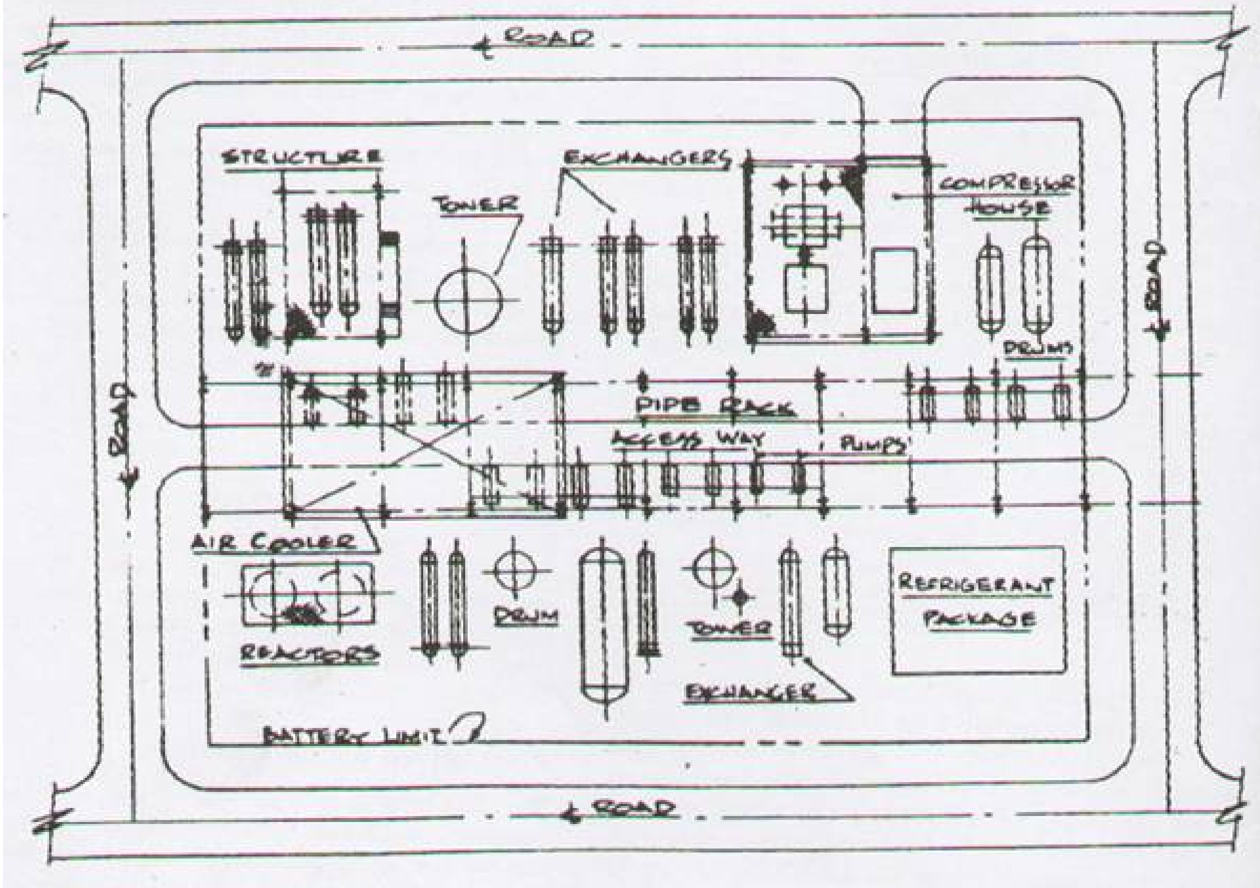
Sample Construction Plot Plan

DWG. NO. LPP 23

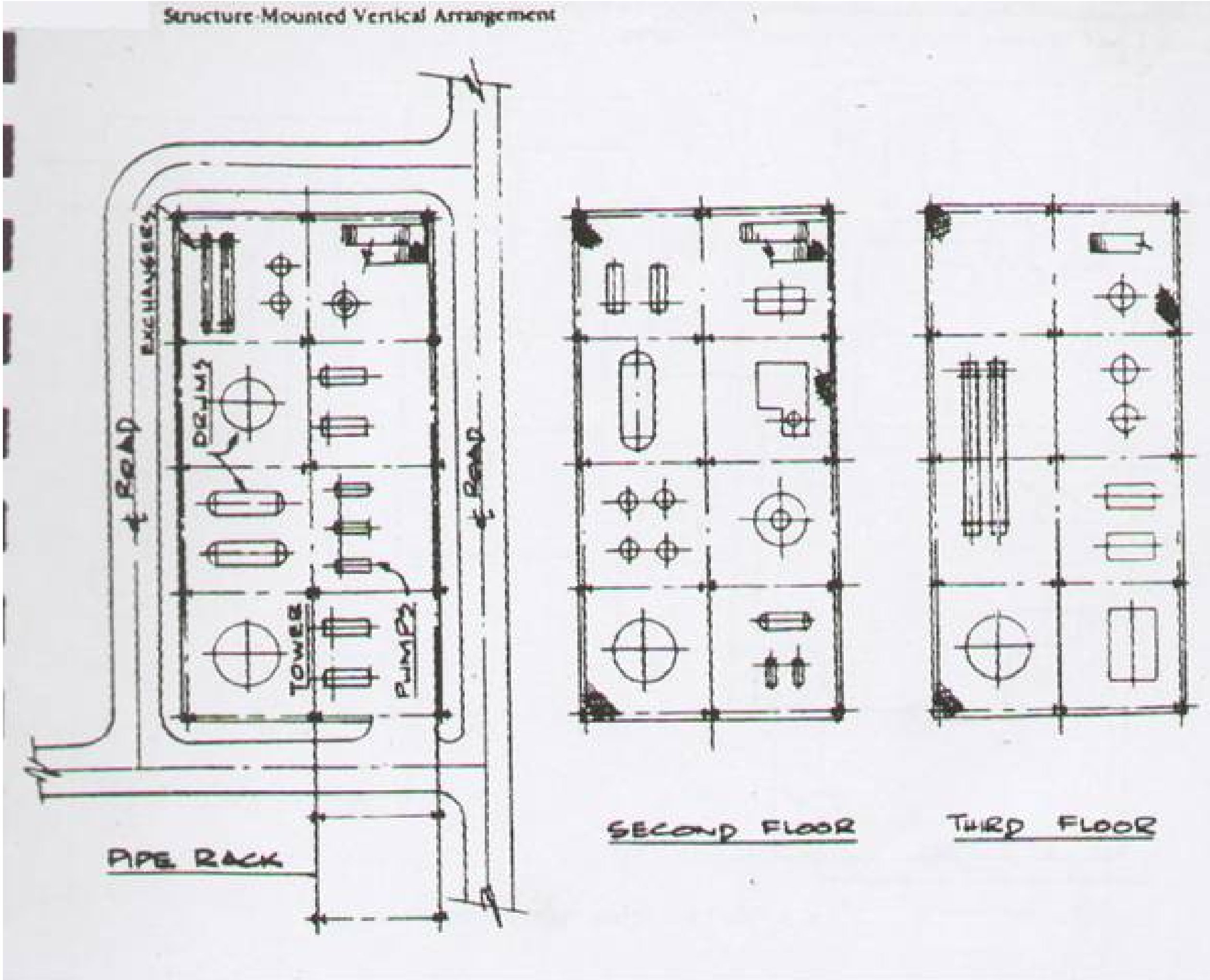

Sample Process Flow Diagram
NAPHTHA 105°F
CHARGE FURNACE
101-F
800°F
101-R
REACTOR
101-D
FEED SURGE DRUM
CHARGE PUMPS
101-P
105°F
275°F
750°F
320°F
106-E
EFFLUENT COOLER
107-E
FEED EXCHANGERS
104-E
TRIM COOLER
175°F
STEAM
101-C
RECYCLE COMPRESSOR
SUCTION DRUM
102-D
OVERHEAD CONDENSER
180°F
105-E
TRIM CONDENSER
103-E
101-T
STRIPPER
120°F
105-D
REFLUX DRUM
160°F
102-E
FEED EXCHANGER
104-P REFLUX PUMPS
320°F
H2
103-D
SUCTION DRUM
102-C
M
MAKE-UP COMPRESSORS
101-E
REBOILER
103-P
BOTTOMS PUMPS
109-E PRODUCT COOLER
275°F
120°F NAPHTHA
HOT NAPHTHA
NAPHTHA HYDROTREATER

DWG. NO. LPP 25

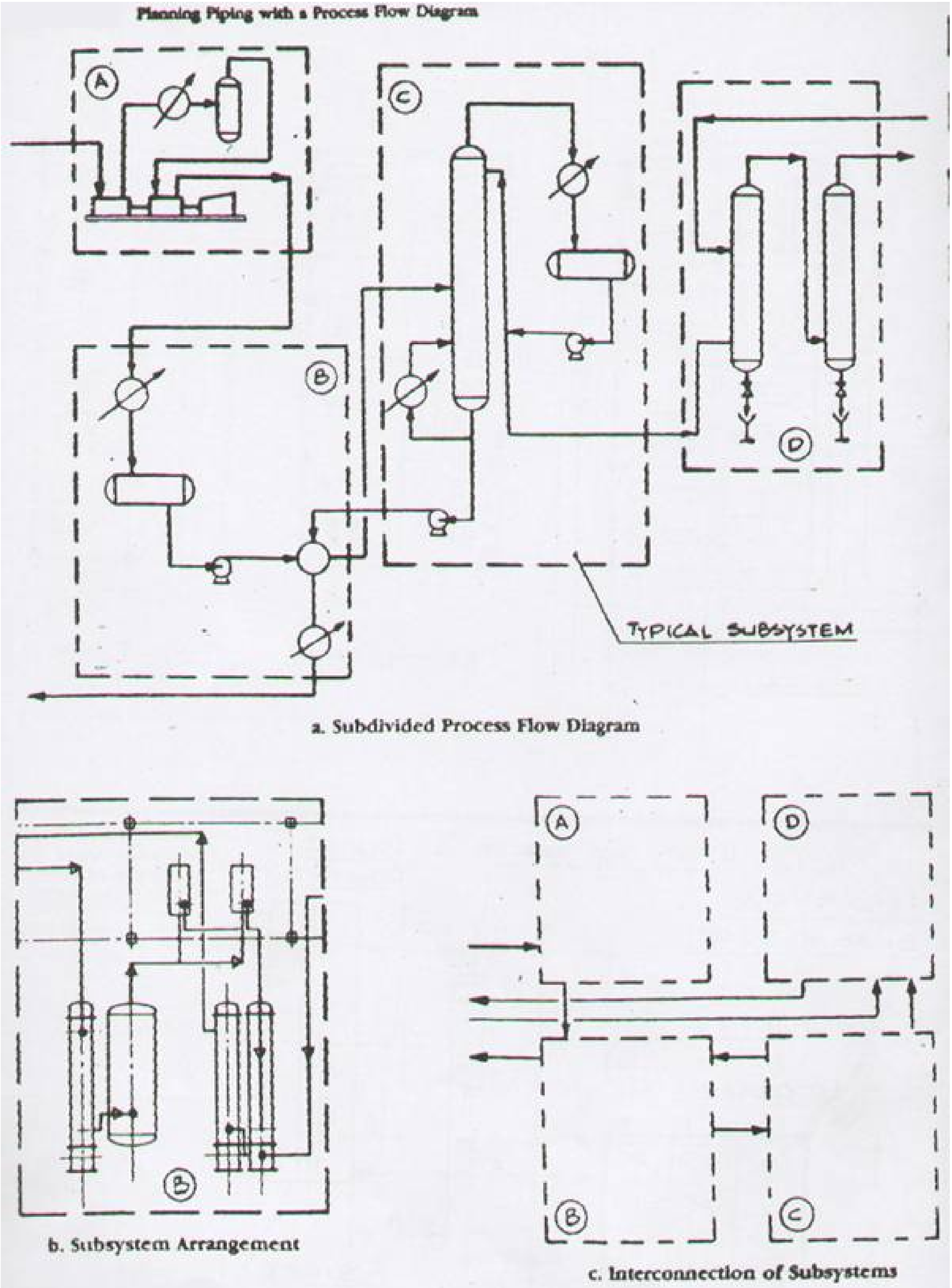
Grade-Mounted Horizontal Inline Arrangement



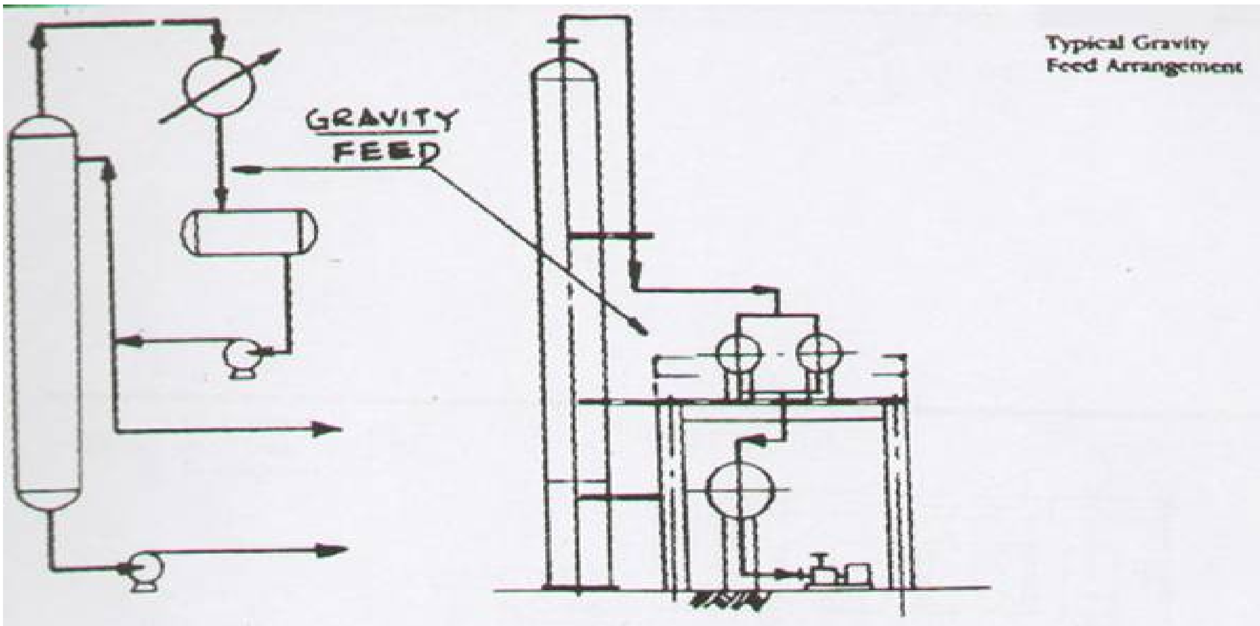
DWG. NO. LPP 26


Structure-Mounted Vertical Arrangement
EXCHANGERS
DRUMS
TOWER
PUMPS
℄ ROAD
℄ ROAD
PIPE RACK
SECOND FLOOR
THIRD FLOOR

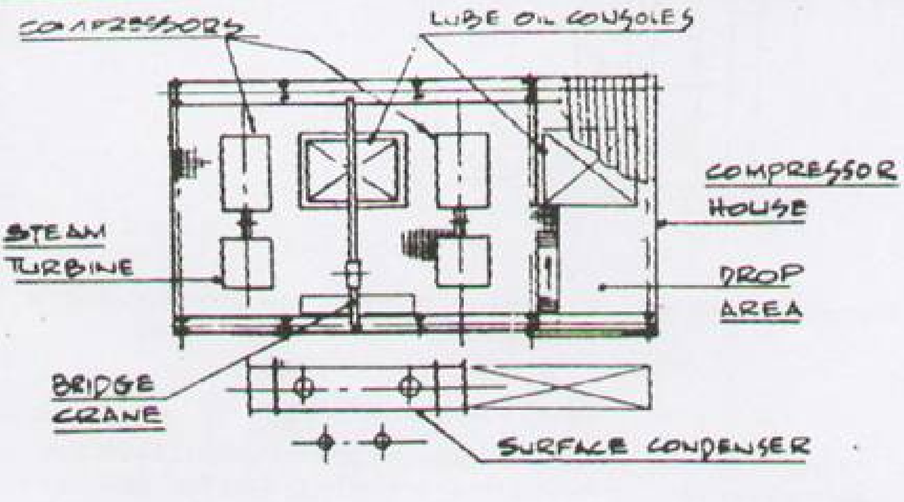
DWG. NO. LPP 27


Planning Piping with a Process Flow Diagram
A
B
C
D
TYPICAL SUBSYSTEM
a. Subdivided Process Flow Diagram
B
b. Subsystem Arrangement
A
D
B
C
c. Interconnection of Subsystems

DWG. NO. LPP 28

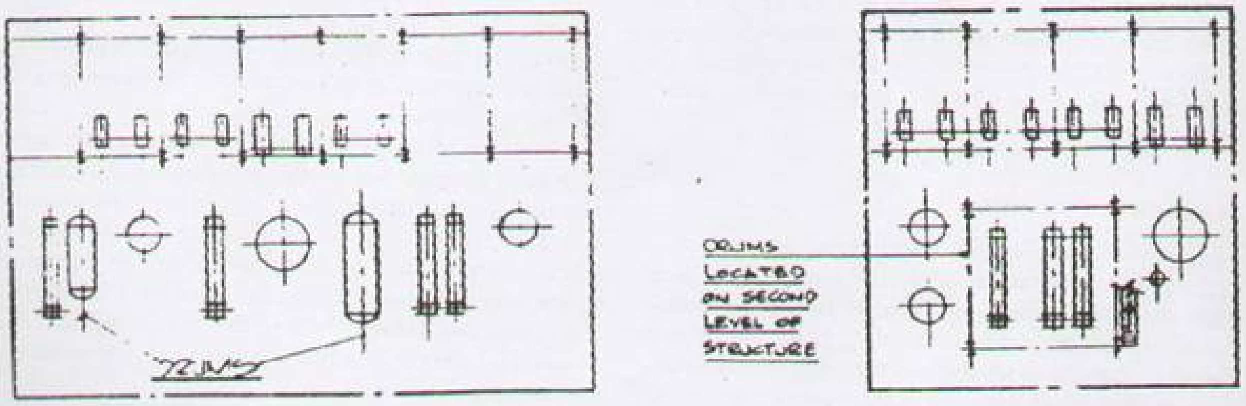


DWG. NO. LPP 29,30



Typical Compressor Area Arrangement

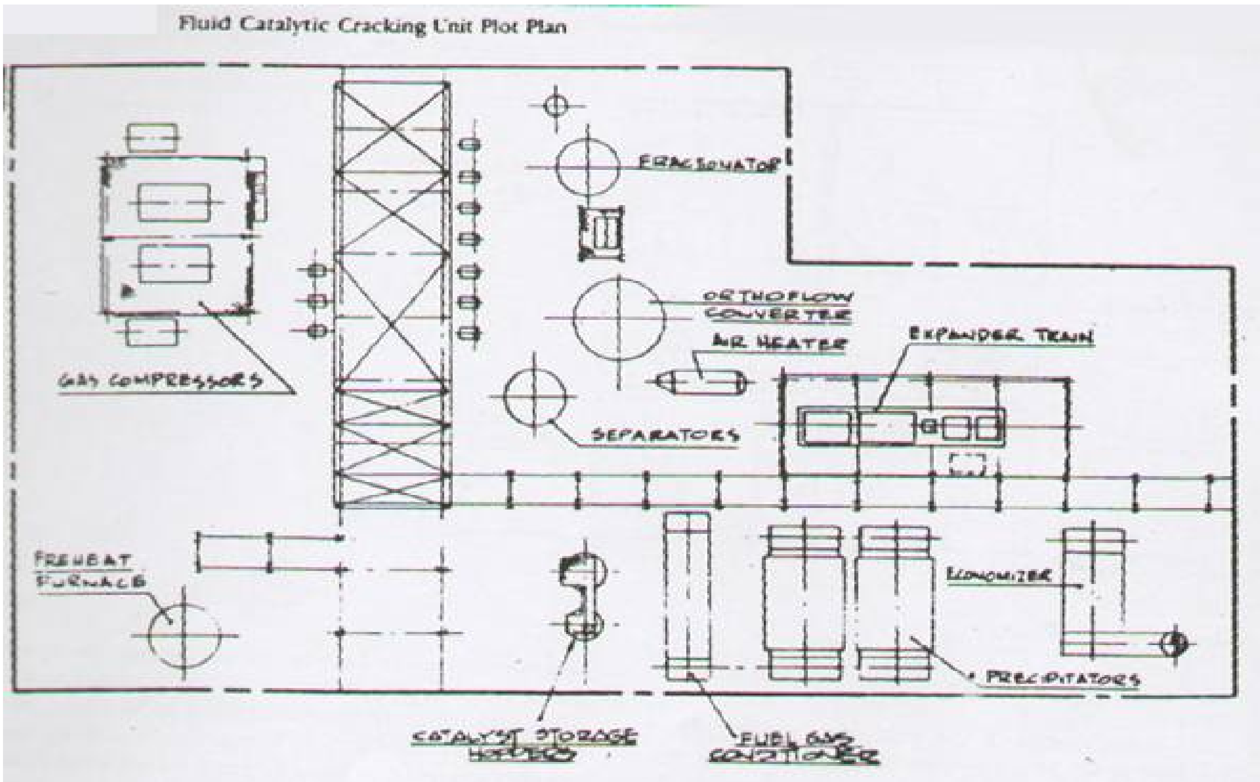
EXHIBIT 3-13 Floor Space Comparison



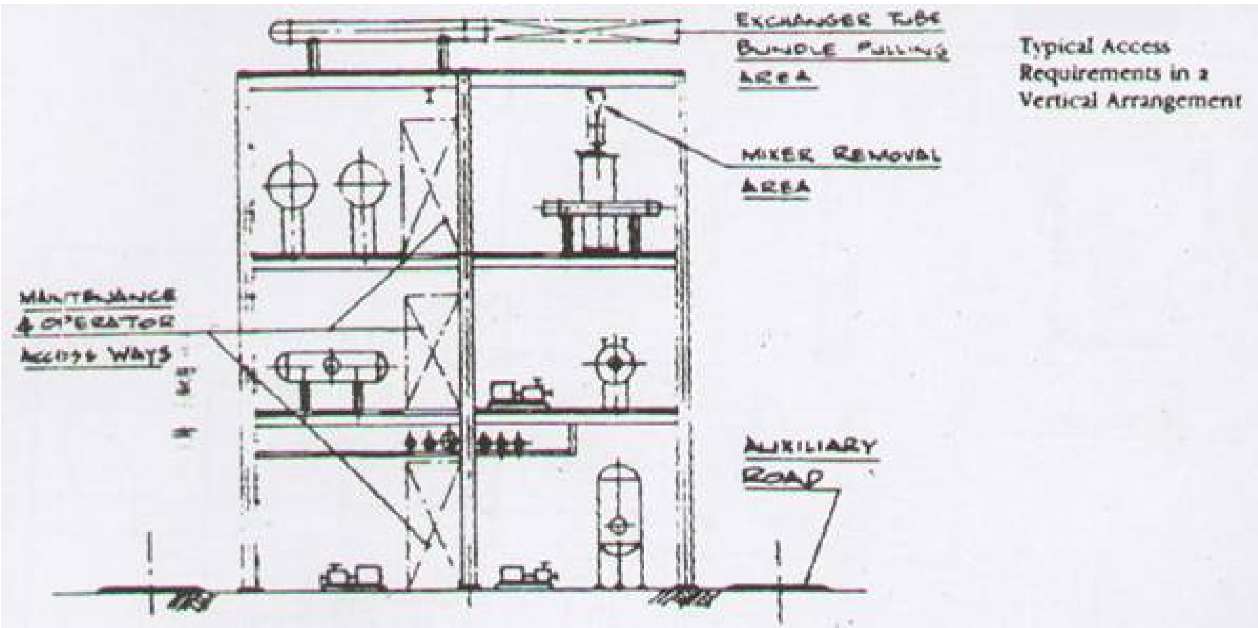
a. Before Minimum Space Adjustment

b. After Minimum Space Adjustment

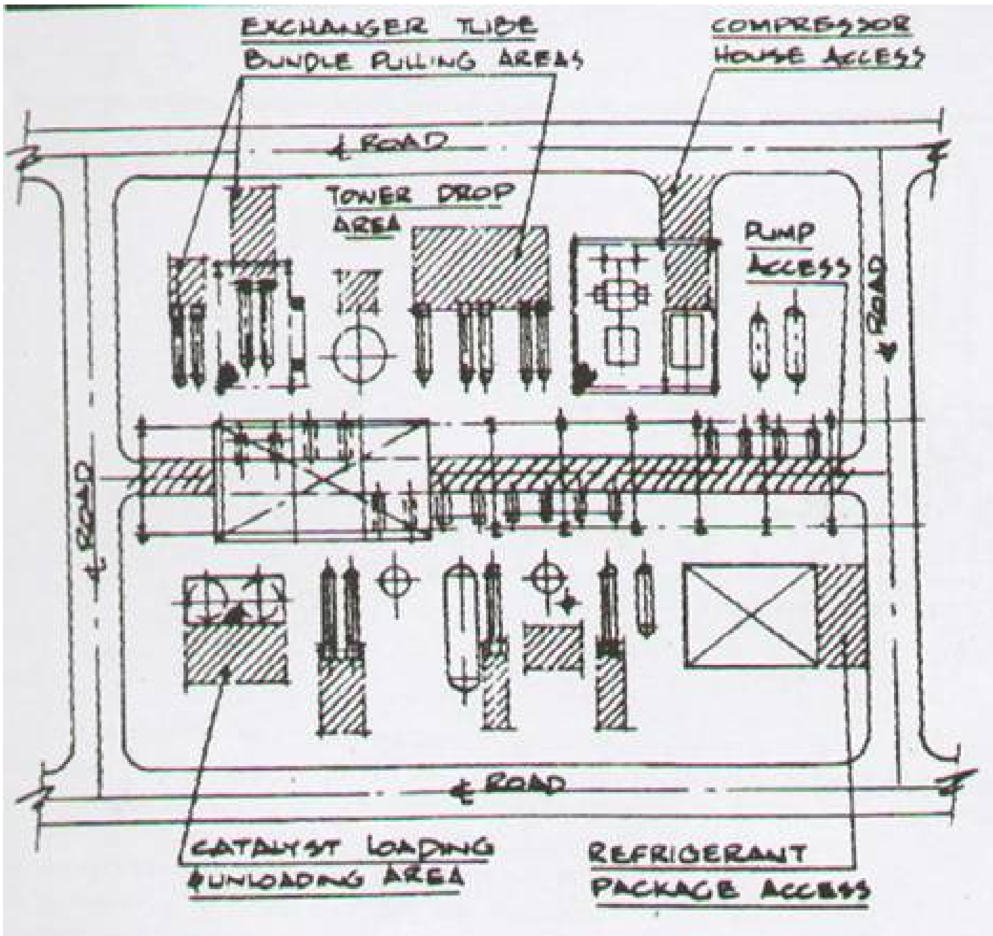
DWG. NO. LPP 31



DWG. NO. LPP 32

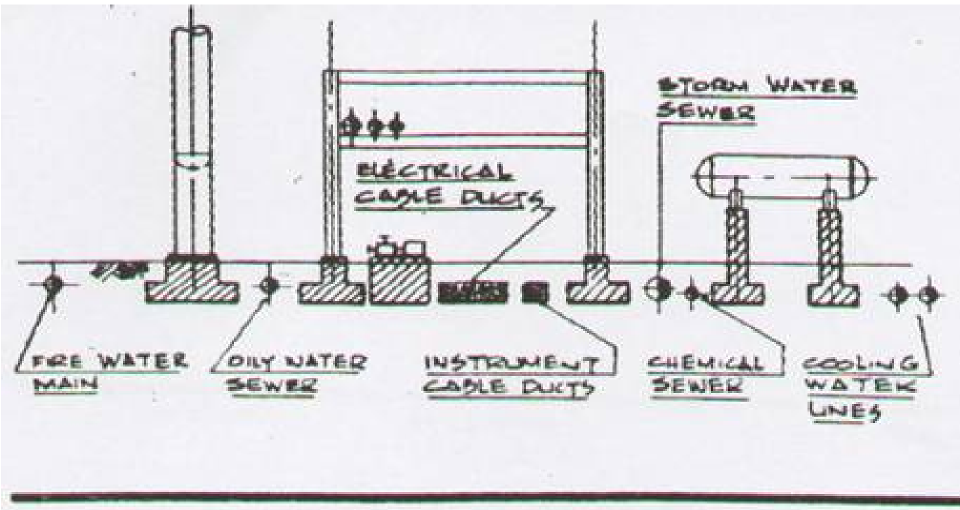


DWG. NO. LPP 33



Typical Access Requirements in an Inline Arrangement

DWG. NO. LPP 34,35



Typical Underground Elevations

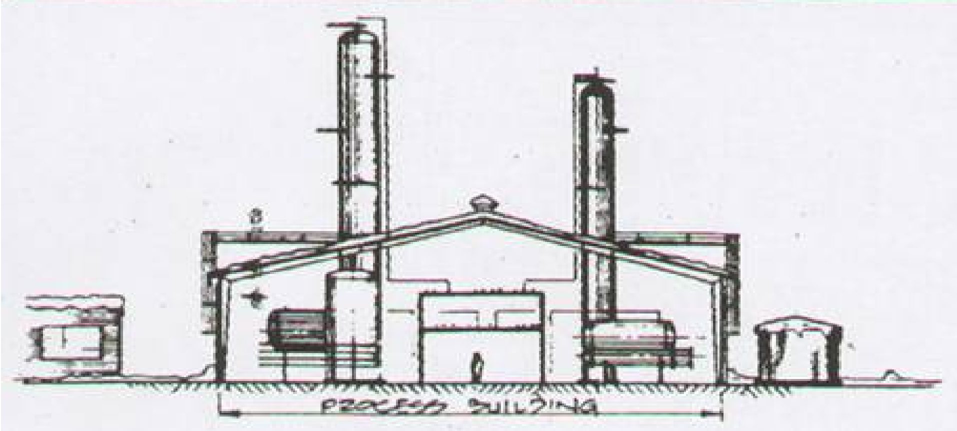
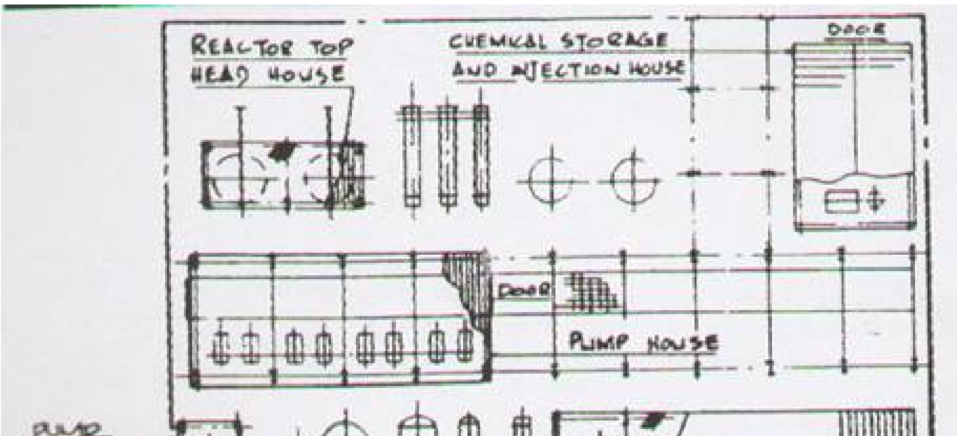


EXHIBIT 3-18
Total Unit Encasement

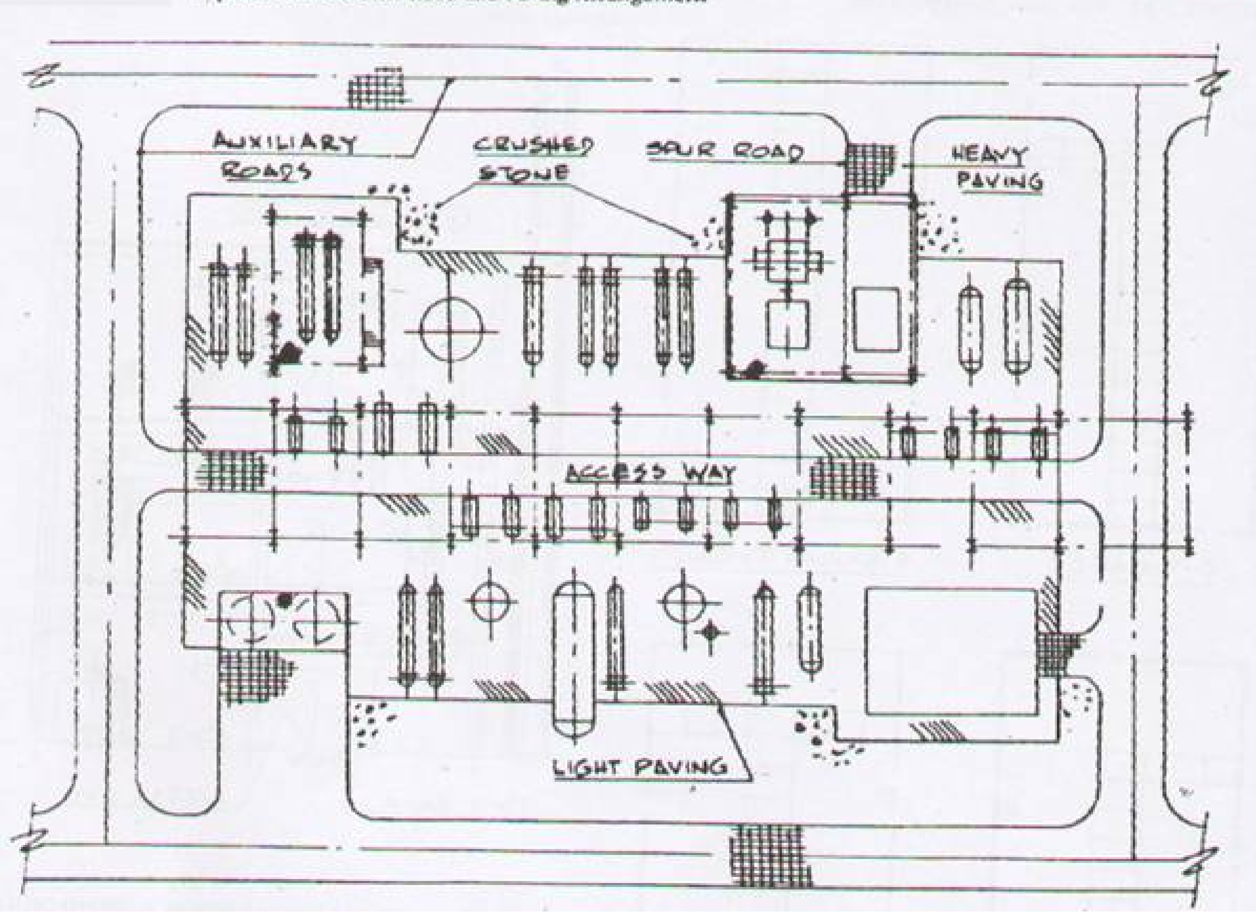
DWG. NO. LPP 36



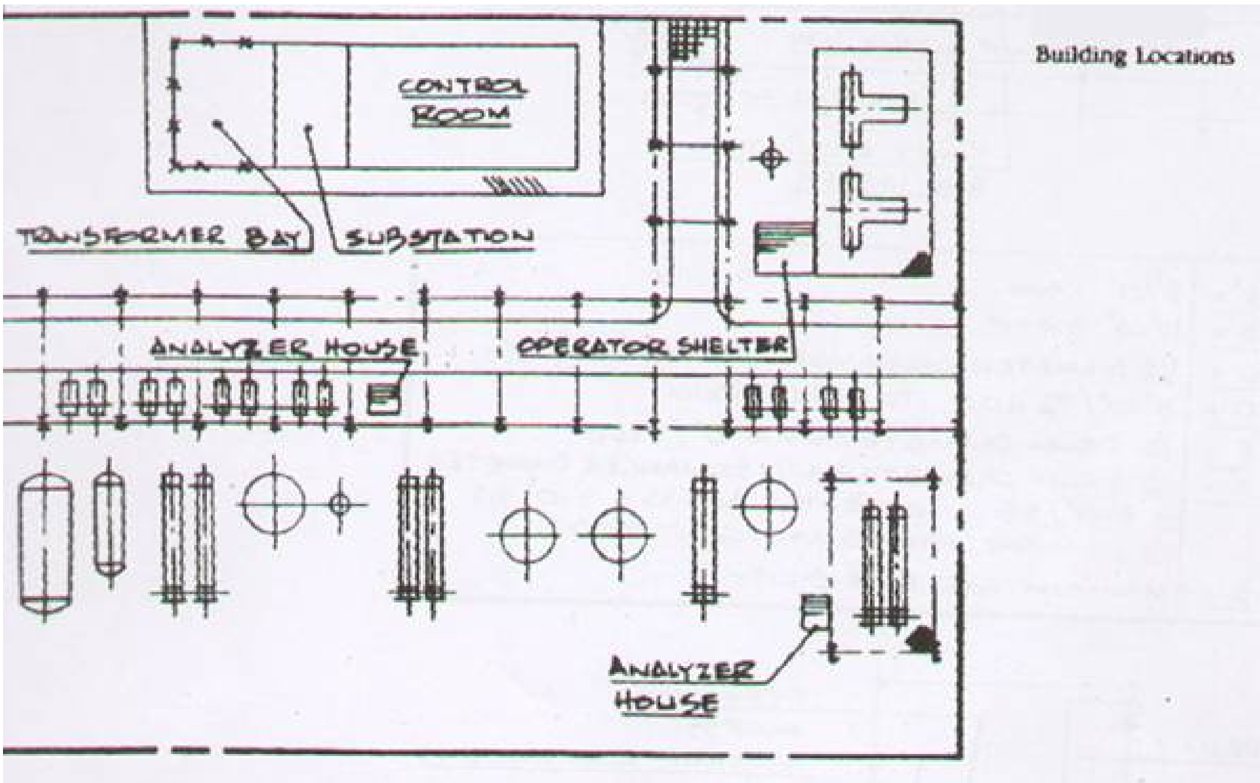
Individual Equipment Houses

DWG. NO. LPP 37

Typical Process Unit Road and Paving Arrangement

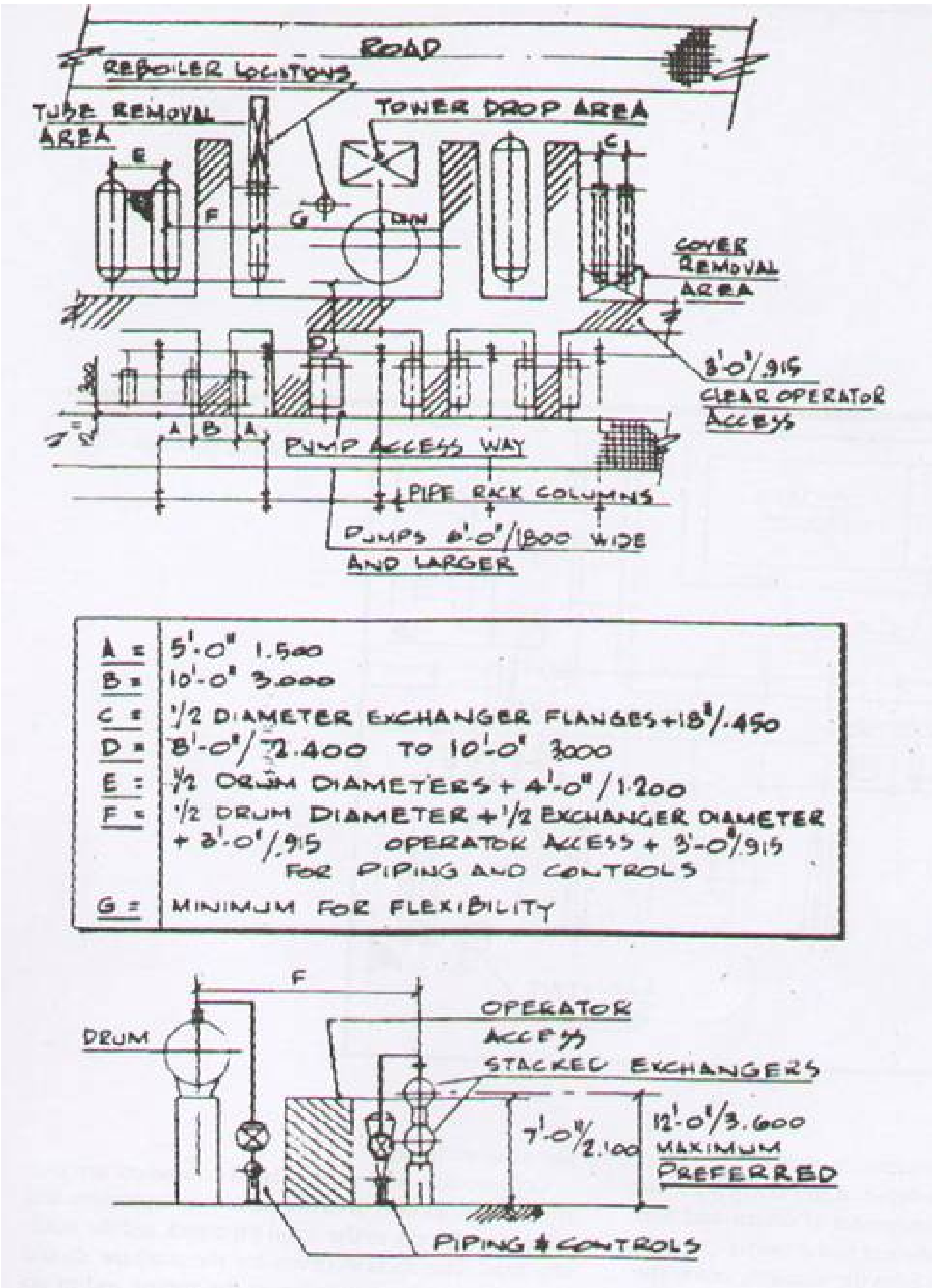


DWG. NO. LPP 38

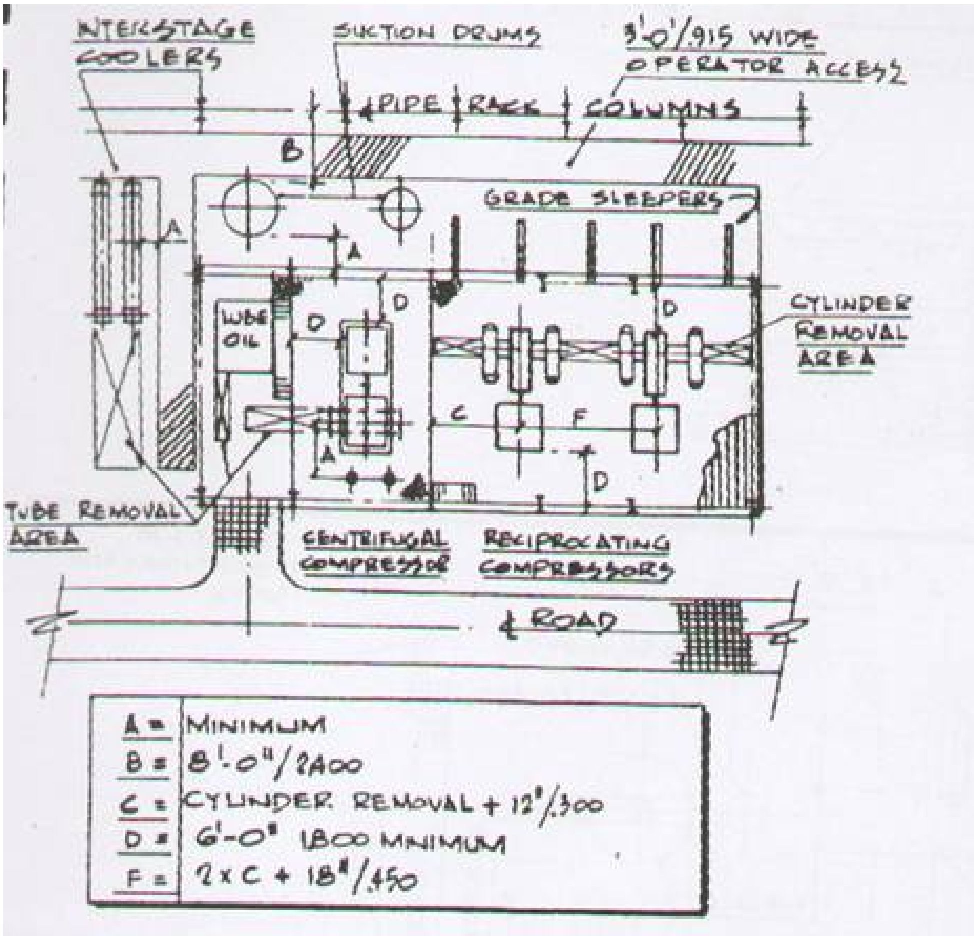

Building Locations
CONTROL ROOM
TRANSFORMER BAY
SUBSTATION
ANALYZER HOUSE
OPERATOR SHELTER
ANALYZER HOUSE

DWG. NO. LPP 39

Typical Tower Area Spacing

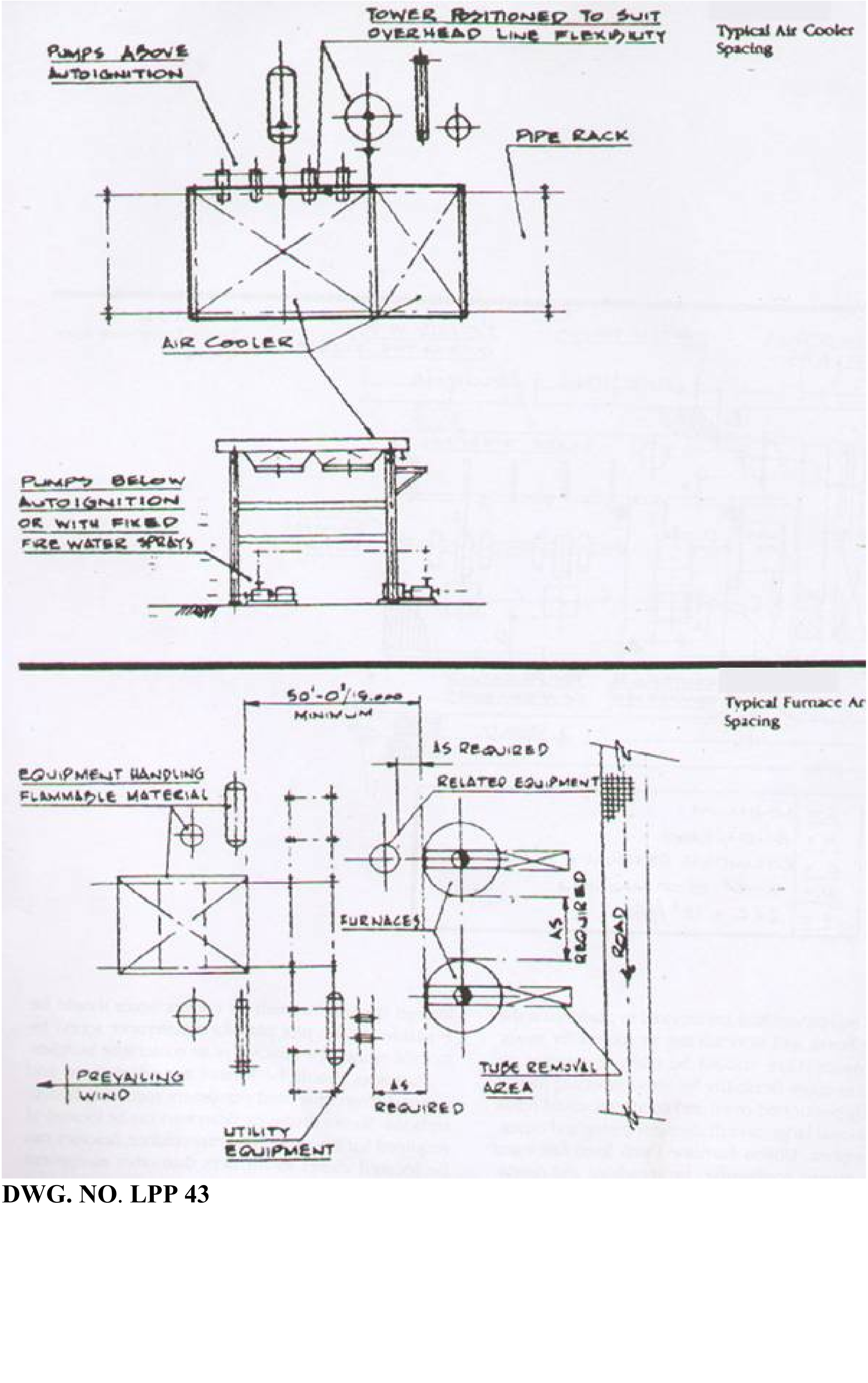


DWG. NO. LPP 40

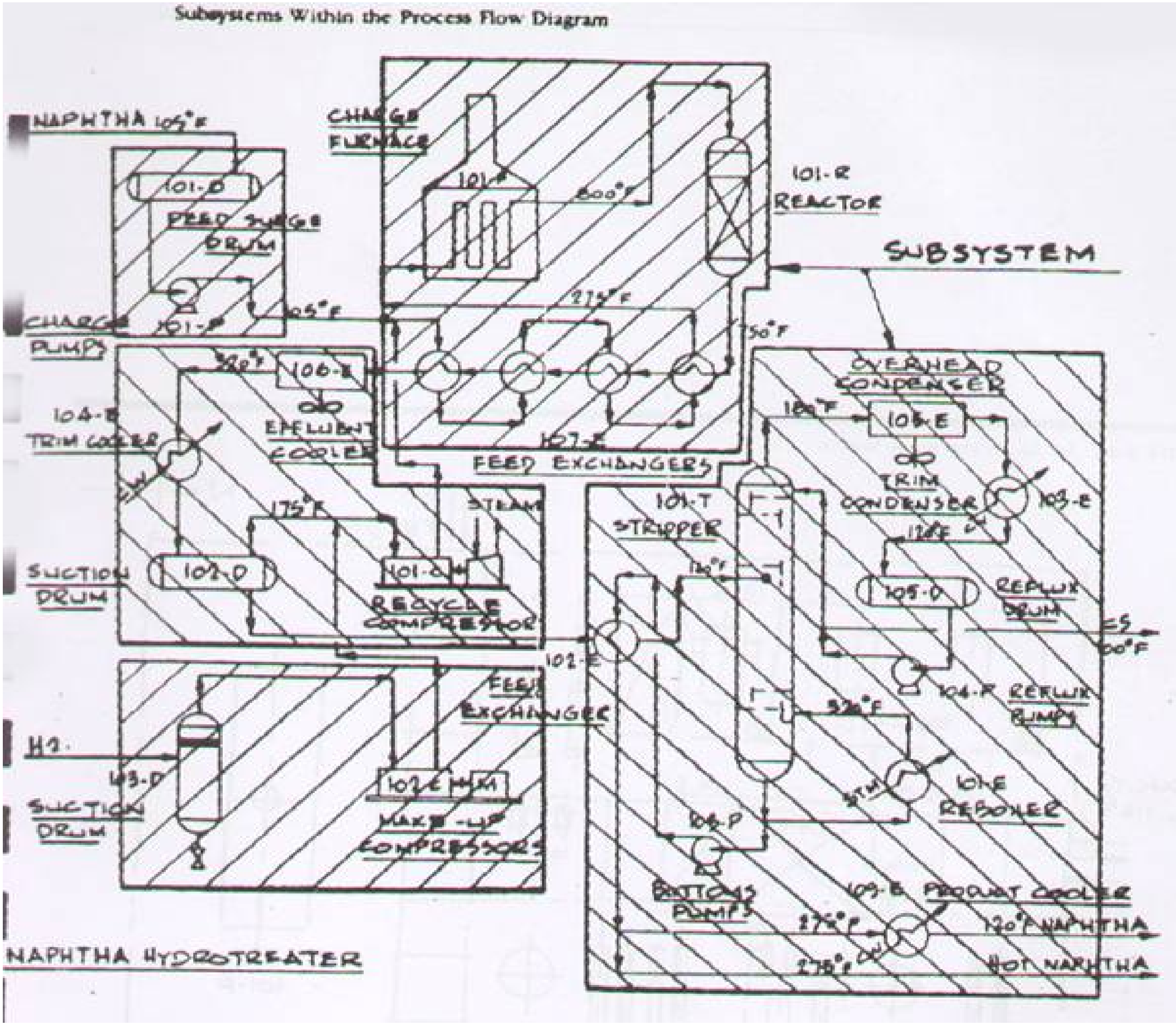


Typical Compressor Area Spacing

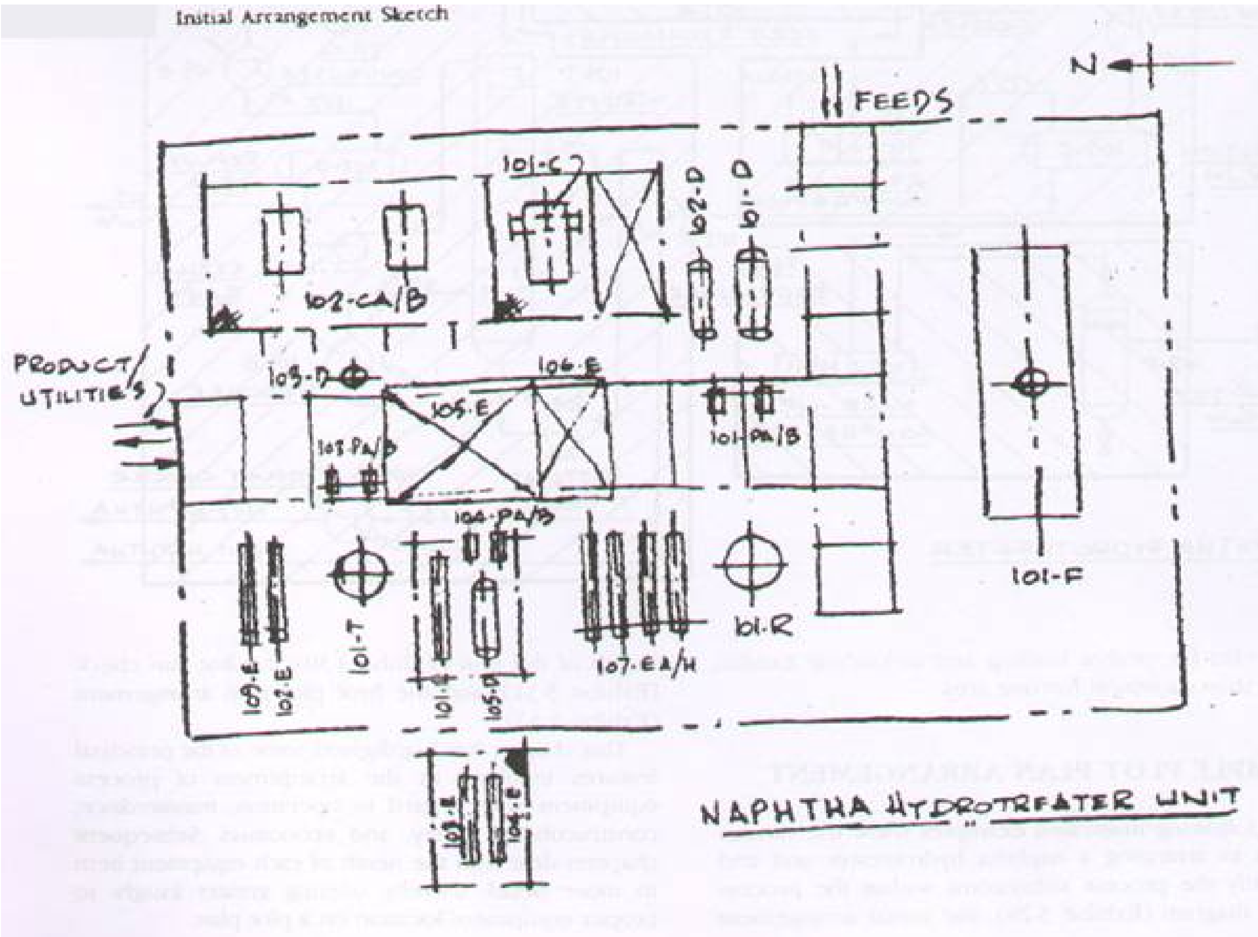
DWG. NO. LPP 41,42


TOWER POSITIONED TO SUIT OVERHEAD LINE FLEXIBILITY
Typical Air Cooler Spacing
PUMPS ABOVE AUTOIGNITION
PIPE RACK
AIR COOLER
PUMPS BELOW AUTOIGNITION OR WITH FIXED FIRE WATER SPRAYS
50'-0"/15.000 MINIMUM
Typical Furnace Ar
Spacing
AS REQUIRED
EQUIPMENT HANDLING FLAMMABLE MATERIAL
RELATED EQUIPMENT
FURNACES
AS REQUIRED
ROAD
TUBE REMOVAL AREA
PREVAILING WIND
AS REQUIRED
UTILITY EQUIPMENT

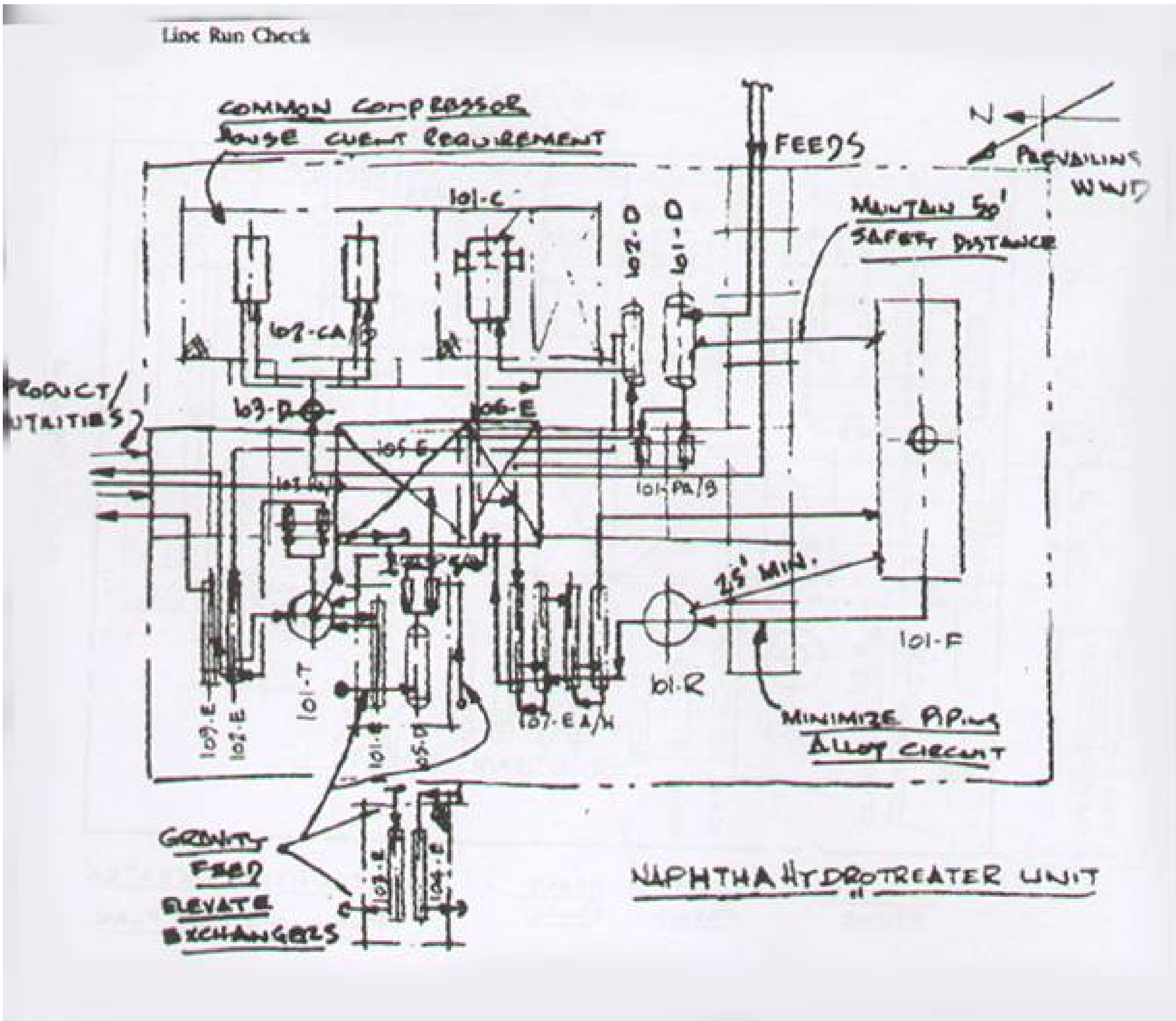
DWG. NO. LPP 43


Subsystems Within the Process Flow Diagram
NAPHTHA 105°F
CHARGE FURNACE
101-F
800°F
101-R
REACTOR
101-D
FEED SURGE DRUM
SUBSYSTEM
CHARGE PUMPS
101-P
105°F
275°F
750°F
320°F
106-E
OVERHEAD CONDENSER
104-E
TRIM COOLER
EFFLUENT COOLER
107-E
FEED EXCHANGERS
180°F
105-E
TRIM CONDENSER
103-E
101-T
STRIPPER
175°F
STEAM
SUCTION DRUM
102-D
101-C
RECYCLE COMPRESSOR
105-D
REFLUX DRUM
102-E
FEED EXCHANGER
104-P
REFLUX PUMPS
H2
103-D
SUCTION DRUM
102-C
MAKE-UP COMPRESSORS
101-E
REBOILER
BOTTOMS PUMPS
109-E
PRODUCT COOLER
275°F
120°F NAPHTHA
HOT NAPHTHA
NAPHTHA HYDROTREATER

DWG. NO. LPP 44


Initial Arrangement Sketch
N
FEEDS
101-C
102-CA/B
102-D
101-D
PRODUCT/
UTILITIES
103-D
106-E
105-E
103-PA/B
101-PA/B
104-PA/B
101-F
101-T
101-R
107-EA/H
101-E
102-E
105-D
NAPHTHA HYDROTREATER UNIT

DWG. NO. LPP 45


Line Run Check
COMMON COMPRESSOR
HOUSE CLIENT REQUIREMENT
FEEDS
N
PREVAILING
WIND
MAINTAIN 50'
SAFETY DISTANCE
101-C
102-D
101-D
103-CA
103-D
106-E
105-E
PRODUCT/
UTILITIES
101-PA/B
25' MIN.
101-F
101-R
MINIMIZE PIPING
ALLOY CIRCUIT
109-E
102-E
101-T
107-EA/H
GRAVITY
FEED
ELEVATE
EXCHANGERS
NAPHTHA HYDROTREATER UNIT

DWG. NO. LPP 46

Final Plot Plan Arrangement