Process Piping - Plant Design and Layout

An Online Continuing Education Course for Engineers

Course Number: M-6024

Credit: 6 Hours / 6 PDH / 6 CPD

Process Piping – Plant Design and Layout

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The piping group has the main responsibility for the design and layout of the facility. Drafters and designers must coordinate their efforts with the civil, structural, process, mechanical, electrical, and instrumentation groups throughout the design process. The piping group must provide each design group the necessary information needed to complete their part of the project and have the complete set of plan and construction drawings finished on time.

Facility design and layout must meet the customer's expectations as well as comply with safety codes, government standards, client specifications, budget, and start-up date. This is to ensure the operating personnel can operate and maintain the system in a safe and productive manner. This may be as simple as providing manual valves to isolate equipment for maintenance or the location of instrumentation for everyday operation.

This 6-hour course will familiarize engineers, designers and construction personnel with layout, design procedures and practices involved in the location of equipment and layout of piping systems. Among other topics that will be discussed are maintenance and accessibility requirements of piping and the latest CAD techniques used in piping layout.

The course will benefit engineers and designers entering the plant design field, piping and design engineers, senior draftsmen, process engineers, mechanical engineers and practicing engineers requiring to expand their knowledge, fabricators, contractors etc.

This course is the 6th of the 9 modules in series that cover the entire gamut of piping engineering in in quick reference. All topics are introduced to readers with no or limited background on the subject. This module is divided in five (5) chapters:

CHAPTER -1: PLANT DESIGN AND LAYOUT

The chapter describes the need for the Plot Plan, key issues and challenges. It discusses the key features in the development of the plot plan – Terrain, Throughput, Safety and Environment. It provides guidance on how to demarcate the site area for process equipment, utilities and service buildings.

CHAPTER – 2: EQUIPMENT LAYOUT

This chapter covers the equipment layout principles to carry out the design activities. It provides the engineering guidelines for locating process equipment, utilities, loading and unloading facilities, pipe

racks and sleepers. The chapter discusses the clearance and accessibility for crane, forklift, tube bundle pulling, and the different equipment such as process vessels, pumps, heat exchangers, furnaces (Fired Heaters), compressors, tank farms and LPG storage tanks. Reference is made to appropriate codes and standards.

CHAPTER– 3: OSHA GUIDELINES FOR STAIRS, LADDERS AND PLATFORMS

The chapter discusses the OSHA guidelines for Stairways, Handrails, Ladders (portable and fixed type), Cages and Wells, Safety Devices, and the layout and access requirements for Platforms (Ladders and Stairs).

CHAPTER– 4: PIPING LAYOUT

The chapter describes the basic principles of piping layout covering safety, grouping, interferences, supports, pipe ways and rack piping. It discusses the offsite and yard piping, underground piping, utility stations, hose stations etc. The chapter provides system specific information for fire protection, compressed air, steam distribution, fuel oil systems. It also provides equipment specific guidelines for Control valves, Relief valves, Strainers, Instrumentation, Column/Tower and Vessel Piping, Heat Exchanger Piping, Cooling Towers, Heater / Furnace Piping, Pump Piping, Compressor Piping, Turbines and Flare Piping.

CHAPTER– 5: PIPING DRAWINGS

The chapter describes the various type of piping drawings, Orthographic Plans, Piping Isometric Drawings and Spool Isometrics. It provides information on the piping Arrangement in 3D Model, CAD layout in 2D and 3-D environment, stages of model review, database capabilities and 3-D software tools.

CHAPTER 1: PLANT DESIGN AND LAYOUT

A process plant is a collection of process equipment, lot of piping and infrastructure such as power, cooling, waste and ventilation systems.

The plant design and development of the layout has three stages viz.

- First, the piping engineers produce site plant and develop overall plot plan - PLOT PLAN;
- Second they develop unit plot plans and equipment location - EQUIPMENT LAYOUT;
- Thirdly after the equipment are in place, they develop major piping in and around equipment - PIPING LAYOUT.

Plot plans, equipment location and piping layout drawings are developed using the plant coordinate system. The design must take constructability, economics, safety, quality, statutory regulations and operation into account.

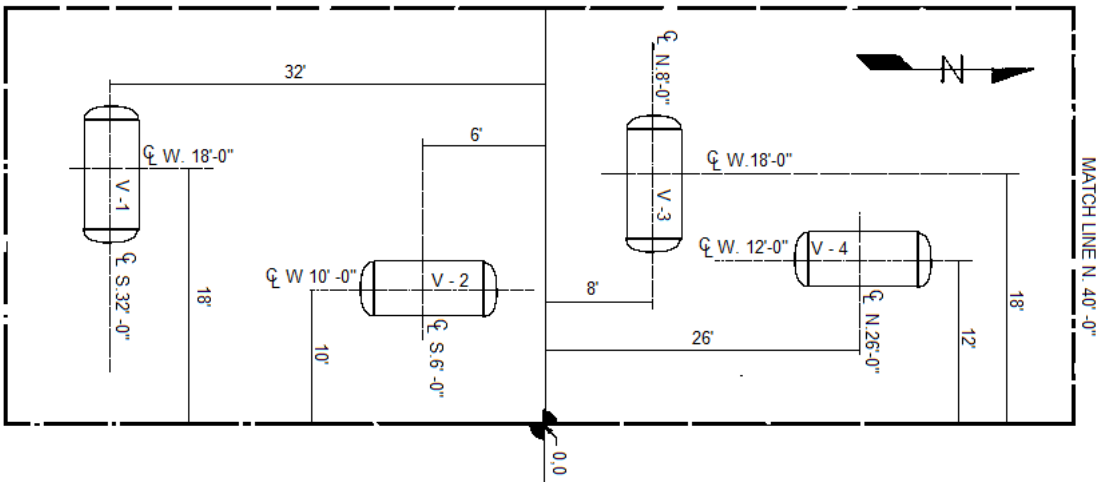
This chapter provides some fundamental engineering principles and good layout practices. The readers must also consult the appropriate codes, standards and the requirements of authority having jurisdiction.

1. PLANT COORDINATE SYSTEMS

Plot plans, equipment location and piping layout drawings are developed using the plant coordinate system. Universally recognized throughout the piping industry, the plant coordinate system uses intersecting grid lines, similar to the Cartesian coordinate system, to locate buildings, structures, foundations, equipment, and piping configurations. These intersecting grid lines, which originate from a designated control point, are drawn parallel to the north/south and east/west axes.

The control point, more commonly known as a bench mark, is used as the origin from which the intersecting north/south and east/west lines are labeled as coordinates using numerical values. The control point, therefore, becomes the primary reference point for the entire facility. By defining the control point as 0'-0", 0'-0" or simply 0-0 and using a **North arrow** to establish orientation, the numerical values assigned to the coordinates allow for exact positioning of all facility components. Coordinates indicate the measurement from the control point to the particular structure, foundation, or piece of equipment that the coordinate locates.

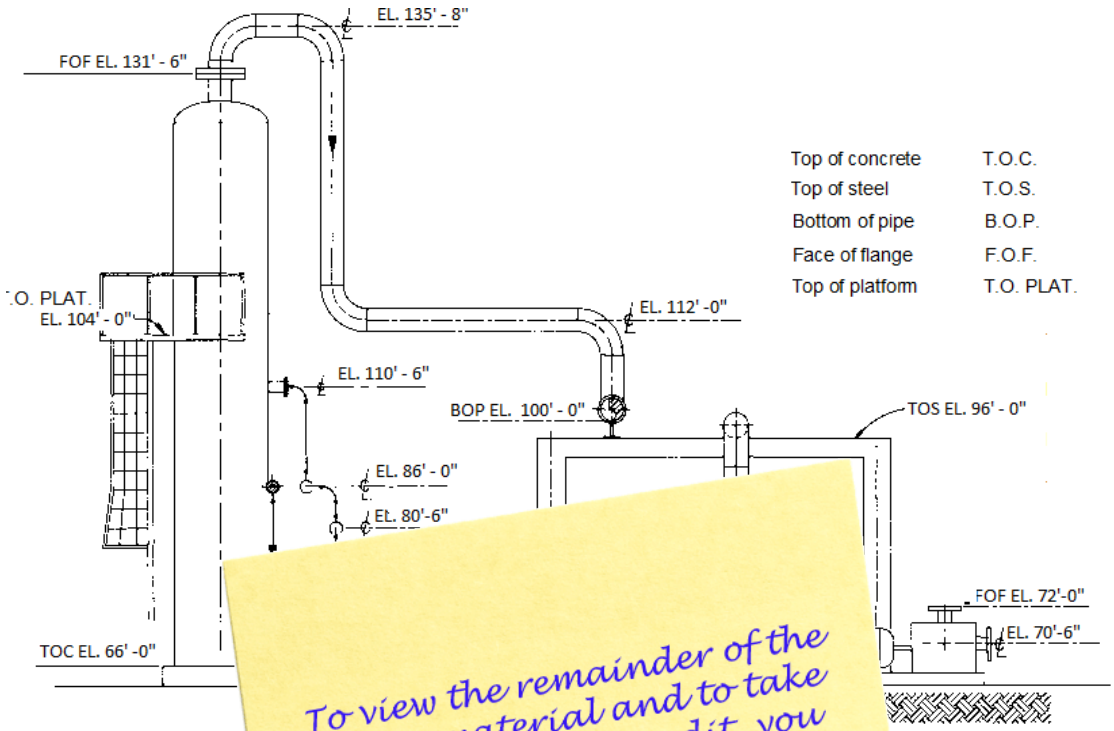
North arrows are typically pointed up or to the right on a drawing and help create directional bearing in the facility. Lines above, or north of the 0-0 control point are assigned North coordinates and are labeled to indicate their distance from the control point, for example, N. 5'-0". Lines to the right of 0-0 are assigned east coordinates, for example, E. 5'-0". Coordinates to the south and west of the control point will have S and W prefixes, respectively. See Figure below for an example of the plant coordinate system.



The format used to identify plant coordinates will vary with each design project. Some projects use feet and inch designations while others may use decimals of a foot or millimeters. No matter the format, all coordinates are preceded by the letters N, S, E, or W.

Location dimensions used on the General Arrangement (GA) drawings are placed to reference a known coordinate, usually the center line of a column, foundation, or piece of equipment.

A control point is also used to establish the elevation of the piping facility. Elevation is the vertical distance an object measures above sea level, such as the height of a mountain. Piping facilities use elevations to designate the height an object measures from grade. **Grade** is a piping term that is synonymous with ground. Rather than using numbers based on the actual height above sea level, most facilities use an arbitrary elevation of 0'-0" as a matter of convenience. Facilities located within high-rise structures may use elevations based on the height of the various floors within the structure. In all petro-chemical facilities, pipes are installed both above grade and below grade. The use of 0'-0" as a point of reference prevents the use of negative numbers when dimensioning lines below grade. Few actual dimensions are provided on piping section or elevation drawings. However, numerous callouts are placed on drawings to convey elevation information to the reader. Refer figure below showing the plant elevation system.



Always use coordinates to c lculate vertical dimensions. By adding or su pports, foundations, and equipment can be deter be confusing, however. The basic rule to re act like coordinates and add unlike coordinates.

Calculating vertical dimension lower elevation from the higher elevation to determine the dis ...0. However, you must be certain that elevations of the same type are used. For example, always use two centerline elevations, not one centerline and one bottom of pipe. It is best to convert B.O.P. elevation callouts to centerline elevations before subtracting. This is accomplished by adding one half the actual OD of the pipe to the B.O.P. elevation. Also be aware that lines installed below grade are labeled using invert elevations. Invert elevations identify the inside bottom of pipe elevation, that is, the distance from the bottom inside of the pipe to the ground above it.

1.1. SITE PLAN

Site plan is a large scale map of a construction site showing top view of the entire plant and adjacent areas than may include roadways, railways, harbours, ship channels, and aircraft landing zones. Drawings of this size do not show significant detail. Detailed areas of the facility are usually denoted by rectangular outlines with notes or titles describing the area's purpose. It shows: