Piping Design – An Introduction for Non - Piping Engineers

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This paper attempts to explain some of the salient piping activities (along with their sequence) and interaction with other disciplines during detail engineering. Piping Engineers and Designers may find some of it too rudimentary. This is deliberate. The constraints have not been touched upon. Moreover, any single write-up based on a typical job cannot do justice to vast number of activities that a piping team performs.

1. Development of Equipment Layout:

This is arguably the most challenging single activity because almost all input except Process P&IDs and Engineering Design Basis is fluid. The challenge involves creativity, ability to draw upon experience of similar jobs, provisioning for unexpected changes and resolving often conflicting requirements. The major inputs and points considered are:

a. Plot Plan with clear demarcation of Units
b. Process P&IDs and PFDs (Utility Distribution P&IDs are received later because these are based on equipment layout).
c. Indicative Layout, if available (normally for Licensor Units)
d. Engineering Design Basis
e. Statutory Requirements
f. Tentative Dimensions of Equipments/ Packages
g. Connectivity and Access for Maintenance and Erection
h. Critical Piping Circuits e.g. Transfer Lines and Reboiler Lines
i. Aesthetics

The equipment layout thus prepared is sent to almost all major disciplines and Client for their comments. These comments are then consolidated and the conflicting ones are discussed across the table. The layout is now ready for dissection by core group of senior piping people, and this experience of being grilled and cross-examined is a ritual that signifies coming of age of a piping engineer. Changes which affect others are once again taken up with respective disciplines. This layout is then put up for Apex Review. The approved version is the basis for further engineering by Piping and many other disciplines e.g.:

Structures: for Foundations and Super-structures
Instrumentation: for Cable Routing

Electrical: for Area Classification and Trench Routing
General Civil: for Pavement Drawing
Process: for Development of Utility P&IDs
Construction: for Erection Planning, Hard Stand Arrangement, etc.
Cross-reference purpose by many e.g. an SED Engineer while preparing his input for Mechanical Tender would need to refer to this Layout for Levels.

2.Zone/Area Division:

The approved Layout is divided into areas (Area Division). While the old concept of an area was what an A0 size drawing could cover in a particular scale (and this concept has its merits), the trend in this era of 3-D Modelling has shifted to zones. A particular zone covers synergic specific areas e.g. a particular Tech Structure would be covered in a single zone instead of three or four areas. Similarly, one may find the whole pipe-rack of a medium sized unit carved in two zones instead of eight to ten areas. Once this division is over, specific area/zone wise responsibilities are assigned for Studies, Modelling, MTO and Flexibilty Analysis. This is also the time when team formation takes place.

3.Piping Studies:

The adage that piping study is 'half science and half art' is true. The art part is visualization and creativity while science refers to following the established norms; however, what is forgotten is that a piping study involves lot of dedication, risk-taking ability and discipline. A piping designer is at work 24 hours. A good scheme, solution or an alternate striking at midnight is not uncommon, something akin to Archemides and Eureka! Many a times the designer would also have to release fronts for downstream users even when the input is still coming and then he must constantly be on the vigil for changes in input. A good designer knows not only how he is affected by others but also how his work affects others. By-products of a piping study are:

a. Confirmation/comments on Structural Foundations and Super-structures (this also involves additional associated information e.g. openings, brackets, loads, bracings, approach, etc).
b. Confirmation/Comments on Locating Dimensions (including Centre-line and Bottom Tangent Line Elevations) of Equipments.
c. Miscellaneous platforms – connecting ones (including walkways), independent ones and the ones required on equipments (the latter enables structures to release platform cleats).
d. Comments on Setting Plans of Exchangers – identification of fixed support, saddle-to-saddle distance, orientation of davits, pipe clips, piping loads on nozzles, etc.
e. Comments on Air-cooler Setting Plans
f. Comments on Mechanical Datasheets – identification of fixed support, davit arm length and height, pipe clips.

g. Nozzle Orientation of Columns and Vessels
h. Comments on Compressor and Pump Drawings
i. Firming-up of interface for packages e.g. for Dosing Skids, Heaters (Burner Piping), Chillers, Ejector Systems, etc.
j. Firming-up of route of Instruments Cable Trays, Electrical Trenches, Fire-water system
k. Battery-limit interface
l. Front for 3-D Modelling (recently, some of the simpler layouts are directly being attempted on 3-D)
m. Preliminary and part of Intermediate MTO
n. Front for Flexibility Analysis

4.Piping MTO:

Material Take-off is usually done in three stages (Preliminary, Intermediate and Final), followed by Top-up, if required. The time-line typically is beginning of the project (just after issue of Equipment Layout), middle of the project (around 50-60% piping progress) and towards final stages of engineering (over 90% piping progress). The first one is a total manual affair and the emphasis is on long delivery items. For intermediate MTO, material dump is taken from Model and the balance is made up manually, while the final MTO is almost totally taken from Model. Material substitution is also used to the extent possible in order to control surplus generation. Relative merits and constraints of roll-on MTO vis-à-vis the conventional mode have been discussed within and outside the department, and are still a matter of debate.

An integrated state-of-art software called IPMS has been developed in-house (by ITS with active help from user departments) and this caters to MTO Processing and almost all related downstream activities e.g. Material Requisitions, Preparation of TBAs, Purchase Requisitions and Material Control Functions right up to issue of material and maintaining records at site. (In fact, IPMS also caters to some of the upstream activities e.g. preparation of PMS and VMS).

MTO is followed by preparation of Material Requisitions, evaluation of offers and issue of Purchase Requisitions. Hardcopies days are over, and the new interface is through PDF files in a CD. Some Piping MRs involve input from other departments (e.g. from Electrical for MOVs); in this case, Piping acts as a coordinator too. For some items e.g. special valves, expansion joints, etc., vendor drawings are received, commented upon and approved.

5.Mechanical Tender:

The intermediate MTO (some times even the preliminary one) forms the basis for piping part of Schedule of Quantities. While most of it has been automated through the IPMS Package, some special requirements have to be fed in manually. The other departments that piping receives input from are Static Equipment (including Heat Exchangers), Rotating Equipment, Package Equipment, Civil/Structures, Instrumentation, etc. Again, all exchange within EIL and with potential contractors is through soft files only. The related activities involve answering to vendors' queries, attending pre-bid conference and evaluation of offers (preparation of TBA).

6.3-D Model:

The two popular platforms are PDS and PDMS and lot of customization and efforts have gone into reaching the stage that we are at. While for most of the jobs, Piping and Structures have been the only ones involved, Instrumentation and Electrical have also been attached in few jobs. Apart from modeling Lines, Piping also models equipments. At present, Structure is being modeled to facilitate clash detection and review of model (this means that structural deliverables are not being taken from 3-D) and the P&IDs are not yet available on these systems in EIL. Modelling does initially take more time but the rewards are generous:

a. Excellent Visualization
b. Detection of Clash
c. Isometric and GAD generation from Model
d. Correct MTO
e. Client Review from Operability and Maintenance point of view
f. Preservation of Model and Records for future

7.Flexibilty Analysis and Supporting:

The circuits are taken up for analysis in order of criticality i.e. the critical the circuit, the earlier it is taken up. Criticality is a function, among other things, of size/ temperature of line and sensitivity of connected equipment. Other considerations like two phase flow, wind and seismic requirements too play a part.

The tools most often used for formal analysis are Caesar, AutoPipe and oodles of supporting sense. In fact, a good designer anticipates the needs of stress and support engineer and saves lot of hours and rerouting by interacting with the latter at right time. It is important too for continuous dialogue between Piping team members and their structural counterpart for supporting arrangement and loads.

8.Other activities:

There are many other activities that a piping engineer undertakes but which could not be touched upon (due to paucity of time and space):

a. Interaction with Process Licensor including review of P&IDs

b. Preparation of Piping Design Basis
c. Manhour Estimates, Scheduling and Progress Reporting
d. Piping Material and Valve Material Specifications
e. Ensuring compliance with Procedures, Work-instructions and Check-lists
f. Under-ground Piping
g. IBR Package
h. Painting and Insulation Tender
i. Input to other Tenders e.g. Civil/Structural Tender
j. Arranging 3-D Model Review by Client/PMC
k. Issue of Design Change Requests/Notes and Manhour Change Orders
l. Input for Package Units and Review of Documents/Drawings of Package Vendors
m. Record keeping and importance of Document Control e.g. maintaining indices
n. Site interface and support/co-ordination
o. Trouble shooting
p. Revamp Jobs
q. Standardization (e.g. Updation of Specifications, Technical Notes, databank for Deviations granted, ensuring latest supply of Codes and Standards, Technical Evaluation of New Vendors, etc.)
r. Managing a team of twenty to thirty people, keeping them motivated and making them feel important
s. Interacting with almost all major disciplines and resolving input conflicts

Summing Up

Piping in a plant has often been compared to arteries in human body. The connectivity, and hence the coordination, done by a piping engineer is enormous. In fact, there would hardly be a department not having interface with piping. This can also be gauged from the fact piping consumes almost half the engineering manhours of setting up of a typical refinery, petrochemical or gas unit. Appreciation of piping sequence of work by others and knowing how & where do their inputs fit in shall result in better quality deliverables.

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