Overview of Current Piping Design Aspects

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Abstract- *Effective piping design is depends on ratio of its durability to cost, which depends on analysis of installment budget, capacity, product quality measures also on process parameters of piping installation, ease of maintenance and future scope for the expansion. Piping design gives summary of significant product and process parameters to be considered defined. In spite of routine design procedure there are several factors like seismic loads, thermal stresses due to earth, and consideration of natural hazards is also important. This paper gives brief idea about vision for design and manufacturing consideration of piping design also it gives an overview of different piping standards which are significant for particular application field.*

Keywords- Industry Codes and Standards, Pipeline Coating, Surface Live Loads etc.

I. INTRODUCTION

Geothermal piping is mainly distinguished between piping inside the power plant and site transportation of steam. The endurance of safety and economical steam, multiphase flow transportation to destination with minimum losses is the key of effective piping design. Transport pipelines run through country over the roads with steep slopes and prominently through the areas affected by seismic load conditions. Two major factors affect the piping design is design procedure and deliverables of project. The scope of this paper includes understanding different parameters that will affect design considerations of geothermal piping.

II. DESIGN CRITERIA AND PARAMETERS

Design criteria are basis for agreement between customer and vendor for design, build, operate.Sample design criteria are mentioned in Table.2.1 which gives us guidelines for design framework. Before proceeding with the design of the pipelines, some restrictions or assumptions about the characteristics of the production wells, re-injection wells, power plant location need to be considered. The output characteristics, mass flow rates, well head pressure, temperature and chemistry of the wells enable the selection of optimum production values, which will be considered for the entire life of the project. Design procedure is followed by defining customer requirements as mass flow rates, head pressure, working temperature which is necessary for defining capacity and investment of proposed project. Also it is essential to understand design boundary condition during bidding stage itself.

2.1 General Pipeline Design Considerations

So general piping design consideration includes critical design aspects such mass flow rate, start to end point travel map of piping, separation and location between pumping station with desired capacity, maximum allowable working pressure (P_{max}),Hydraulic and design calculations of piping.

Table 2.1: Sample Design Criteria

General	Process	Mechanical	Civil/Structural
Design aspect	Steam field layout	Design Parameters –Process conditions – Design Loads	Design codes and procedures
Metrological & other local data	Economic analysis	Design codes and procedures	Project layout
Environmental requirements	Piping criteria: -pressure drop -line sizing -pipe routing -design pressure	Piping systems design	Access
Operating and maintenance criteria	Draining& venting philosophy	Pipes	General Civil construction

2.1.1 Safety

Implementation of proper design and safety codes, training operational workforce is key for safety assurance in system. Operating with standardized working practices is possible through corporate safety facilities and government regulations this leads to develop safety analysis of process and standardize the operations.

2.1.2 Industry Standards and Codes

To keep level of standards, professional organizations such as ASME, API, and ANSI have established several codes in the form of criteria for acceptability of design manufacturing and commissioning.

Following summary of standards is considered for piping:

- Manufacture of line pipe (4 API standards)
- Cathodic protection against corrosion (8 NACE standards and guides)
- Welding (15 American Welding Society [AWS] and 1 API standards)
- Pipeline awareness (2 API standards)
- Pipeline wall thickness (API Standard B31.G)

Some of the primary standards governing pipeline design, manufacturing, construction, and operation are as below:

• API standards(including standards issued jointly by ANSI):

- "Pipeline Maintenance Welding Practices," 3rd edition, API Recommended Practice 1107.
- "Welding of Pipelines and Related Facilities," ANSI/API Std. 1104, September 1999.
- "Marking Liquid Petroleum Pipeline Facilities,"3rd edition, API 1109, July 2003.
- "Developing a Pipeline Supervisory Control Center," API 1113, February 2000.
- "Specification for Line Pipe," API 5L, March 2004.
- "Hydrostatic Test Water Treatment and Disposal," API 1157, October 1998.
- "Managing System Integrity for Hazardous LiquidPipelines," API 1160, November 2001.
- "In-Line Inspection Systems Qualification Standard," 1st edition, API 1163, August 2005.
- "Steel Pipelines Crossing Railroads and Highways," API 1102 (1993).
- "Movement of In-Service Pipelines," ANSI/API 1117, August 1996.
- "Computational Pipeline Monitoring for Liquids Pipelines," API 1130, November 2002.
- "Pressure Testing of Liquid Petroleum Pipelines," ANSI/API RP 1110, March 1997.
- "Steel Pipelines Crossing Railroads and Highways," API RP 1102, January 1993.
    - ASTM standards
    - ASME standards

2.1.3 Sizing

System's capacity can be judged through the dimensions of pipes, large diameter pipes are used for delivering high mass flow rates. Change of piping material and viscosity of product define major pressure loss but at the same time care must be taken while determining span between two pumping station with respective to allowable pressure drop. Standards are used to define size and test pressure for given design. Pipe wall thickness plays important role in sizing usually seismic load prone areas and high pressure applications results in large pipe thickness.Line operating pressure and pump capacities and cost mainly affect line size.

2.1.4 Pressure

Operating pressure of a pipeline is determined by the design flow rate vapor pressure of the liquid, the distance the material has to be transferred, and the size of line that carries the liquid. Operating line pressure is analyzed from mass flow rate of fluid, span of travel, piping sizes and vapour pressure of liquid. From this maximum and minimum line pressure can be determined which gives benchmark for pipe material selection.

2.1.5 Pipeline Coating

Transportation of corrosive product is most crucial parameter which affects the design. So corrosion resistant coating can be applied from both interior and exterior as well to protect pipe surface from corrosive environment also reduction in frictional loss is major advantage of interior coatings. Protective wrapping also adds protection against corrosion of pipes and to sustain mechanical damages during installation. In case of transportation of hazardous liquids quality electrical inspection is needed to detect defects like micro cracks.

FIG. 2.1: Coating Newly Installed Pipe for Corrosion Control

2.2 Product Parameters

For Effective pipeline design fluid properties like viscosity, specific gravity, working temperature, compressibility of fluid, pour point needs to take into consideration.

2.2.1 Specific Gravity/Density

Density is amount of weight occupied by liquid per unit volume, So the liquid which is having higher density will need more energy for transportation which will affect mainly piping grade, size and pumping station capacity.

2.2.2 Compressibility

Since most of the liquids are slightly compressible there less effect on liquid pipe design but, it is having major importance when gases are the products of transportation. Hence while designing gas pipelines compressibility of fluid affect the operating pressure of pipelines.

2.2.3 Temperature

Operating temperature of pipeline has direct impact on mass flow rate and pumping station capacity. Because if the operating temperature goes higher than designed limit liquids prone to expand and their volume goes on increasing leads to increased mass flow rates, on the other hand if working temperature goes down viscosity isincreased leads to high energy requirement for transportation. This parameter is significant in cases like crude oils as it contains paraffin base which solidifies when its temperature is lowered so it becomes trouble for transportation with this condition.

2.2.4 Viscosity

Viscosity is resistance of fluid to flow, so for efficient transportation of fluid from one place to another its viscosity must be as less as possible. Increase in viscosity will add drag in fluid against inner wall of pipes.

2.2.5 Pour Point

The pour point is the temperature at the instance where liquids start to flow. It is standard temperature can be obtained from ASTM Standard D-97. According to design calculations if temperature of fluid is less than pour point it is not possible to transport fluid through pumping. Hence for such cases additional attachment for pipe insulation or heating provisions to keep fluid above its pour point is necessary.

2.2.6 Vapor Pressure

Vapour pressures of liquids determine their tendency to transform into its gaseous state. It is function of atmospheric pressure and temperature. It is significant design constraint in piping and pumping design such that liquid should not reach its vapour pressure during its transportation, which will add losses in flow of the fluid.

2.2.7 Reynolds Number

To determine effect of Inertia force on fluid velocity is analyzed through a dimensionless parameter called as Reynolds number. It is used to determine type flow such as laminar, transient, turbulent flow. In case of having a smooth flow without fluid losses it is recommended that laminar flow must exists in fluid ($Re<2100$)

2.2.8 Darcy Friction Factor

The Darcy friction factor is a dimensional number for determining the necessary capacities of pumps as well as the span between pumping stations to generate the desired mass flow rate of a liquids.

2.2.9 Other Design Considerations

a. Thermal Stresses

Working environment or geographic locations in case of underground piping are also need to consider as an load in the form of temperature on piping so it is necessary to take this into consideration while selecting pipe grade so that these thermal stresses should not reach the failure points.

b. Surface Live Loads

In cases of buried pipes undergo several loads like load from earth; also loads from vehicles going on road, constructions on road have influence to specify the strength of piping material. These live loads predominantly affect pipe locations, grade and sizes. Table 2.2 shows requirements of the design specification for live-load pressure, Pp, are given in psi and include an impact factor $F = 1.5$ to account for bumps and irregularities in the travel surface based on HS-20 (AASHTO 1998) truck loads or American Railway Engineering Association (AREA), Cooper E-80 railroad loads (AREMA 2006),American Association of State Highway and Transportation Officials (AASHTO).

TABLE 2.2:- Surface Live Loads

Live Load Transferred to Pipe ($lb/inch^2$)			Live Load Transferred to Pipe ($lb/ inch^2$)		
Height of Cover (ft)	Highway H20a	Railway E80b	Height of Cover (ft)	Highway H20a	Railway E80b
1	12.5	–c	14	d	4.17
2	5.56	26.39	16	d	3.47
3	4.17	23.61	18	d	2.78
4	2.78	18.4	20	d	2.08
5	1.74	16.67	22	d	1.91
6	1.39	15.63	24	d	1.74
7	1.22	12.15	26	d	1.39
8	0.69	11.11	28	d	1.04
10	d	7.64	30	d	0.69
12	d	5.56	35	d	d

a. Simulates a 20-ton truck traffic load, with impact.
b. Simulates an 80,000 lb/foot railway load, with impact.
c. Dash corresponding to Railway E-80, and 1-ft height of cover is not applicable.
d. Negligible influence of live load on buried pipeline.

c. Natural Hazards and Risk of Human Threats

From guidelines of American Lifelines Alliance (ALA) and the Federal Emergency Management Agency (FEMA) pipeline components may undergo man-made or natural hazards like earthquake, floods, wars has to be followed to sustain piping construction from damage.

d. Fire Hazards

While transportation of volatile and flammable materials like petroleum there might be a chance causing heating, stress, So care needs to be taken especially at pumping stations, road crossings

2.3 Hydrostatic Testing

To analyze rigidity of piping design to detect failure points every segment of pipelines has to undergo hydraulic testing in which pipelines are tested for pressure 25% more than its allowable pressure limits according to US federal safety regulations to pass its quality inspection criteria.

III. CONCLUSION

Piping design is concurrent approach which needs simultaneous consideration of design and manufacturing and durable service life of piping construction. Design procedure mainly deals with conformance of parameters with respect to piping standards. Other design criteria's such as geographical parameters, thermal stresses for underground piping, live surface loads. Also product to be delivered also has major influence especially in case of petroleum piping. Hence consideration of these aspects with successful commissioning of plant is necessary for successful and safe working conditions.

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