Pipeline Design and Construction

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Pipeline design

- \[ Q_{mmscfd} = 0.00128084 \left( \frac{(P_1^2 - P_2^2)}{L_{miles}} \right)^{0.51} D^{2.53} \]

For successful implementation of a pipeline project, the following steps are to be considered in general:

1. Market survey - Present & future demand
2. MAOP & Design pressure
3. Map of the preliminary selected pipeline route (L)
4. Pipe Size (D)
5. Wall thickness (t)
Pipeline design (contd.)

6. Pipe specification / grade
7. Bill of materials
8. Total cost estimate
9. Selection of ROW
10. Detailed survey and Preparation of alignment drawings
Pipeline design (contd.)

Load consideration:

- In earlier days, pipeline design was done considering the present load and 15 to 30% increment of load.

- Now-a days, the use of natural gas increased tremendously. As a result the concept of pipeline design has also changed.

- Presently pipeline design is being done considering the present load as well as the assumed gas load of the that particular area for the next 20 years (effective life of the pipeline)
Pipeline design (Contd.)

- Modified Panhandle equation - most useful for transmission pipeline:

\[ Q_{\text{mmscfd}} = 0.00128084 \left( \frac{P_1^2 - P_2^2}{L_{\text{miles}}} \right)^{0.51} D^{2.53} \]

where, \( P_1 \) = Upstream pressure, PSIA
\( P_2 \) = Downstream pressure, PSIA
\( D \) = Inside pipe dia, inch
Pipeline design (contd.)

- $t = \frac{DP}{2YFLJT}$

where,

- $t =$ Pipe wall thickness, mm
- $P =$ design pressure, psig
- $D =$ outside dia of pipe in mm
- $Y =$ minimum yield strength, psig
- $F =$ design factor
- $L =$ Location factor based on class location
- $J =$ welding joint factor
- $T =$ Temp. derating factor
## Line Pipe: API 5L Grades

<table>
<thead>
<tr>
<th>Grade</th>
<th>Minimum yield strength( MPa)</th>
<th>Minimum Tensile strength( MPa)</th>
</tr>
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<tbody>
<tr>
<td>B</td>
<td>241</td>
<td>413</td>
</tr>
<tr>
<td>X42</td>
<td>289</td>
<td>413</td>
</tr>
<tr>
<td>X46</td>
<td>317</td>
<td>434</td>
</tr>
<tr>
<td>X52</td>
<td>358</td>
<td>455</td>
</tr>
<tr>
<td>X56</td>
<td>386</td>
<td>489</td>
</tr>
<tr>
<td>X60</td>
<td>413</td>
<td>517</td>
</tr>
<tr>
<td>X65</td>
<td>448</td>
<td>530</td>
</tr>
<tr>
<td>X70</td>
<td>482</td>
<td>565</td>
</tr>
<tr>
<td>X80</td>
<td>551</td>
<td>620</td>
</tr>
</tbody>
</table>
Design and Location Factor

- Canadian Standards association (CSA) suggests design factor of 0.8 While location factors are:

<table>
<thead>
<tr>
<th>Area</th>
<th>Class Location</th>
<th>ASME</th>
<th>CSA</th>
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<tbody>
<tr>
<td>Deserted</td>
<td>1</td>
<td>0.72</td>
<td>0.80</td>
</tr>
<tr>
<td>Village</td>
<td>2</td>
<td>0.60</td>
<td>0.72</td>
</tr>
<tr>
<td>City</td>
<td>3</td>
<td>0.50</td>
<td>0.56</td>
</tr>
<tr>
<td>Metropolis</td>
<td>4</td>
<td>0.40</td>
<td>0.44</td>
</tr>
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</table>
## Joint factor:

<table>
<thead>
<tr>
<th>Weld type</th>
<th>ASME B31.8</th>
</tr>
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<tbody>
<tr>
<td>Seamless</td>
<td>1</td>
</tr>
<tr>
<td>ERW</td>
<td>1</td>
</tr>
<tr>
<td>SAW</td>
<td>1</td>
</tr>
<tr>
<td>But Welled</td>
<td>0.6</td>
</tr>
<tr>
<td>Spiral seam</td>
<td>0.8</td>
</tr>
</tbody>
</table>
# Temperature factor:

<table>
<thead>
<tr>
<th>Temperature (°F)</th>
<th>ASME- B31.8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 250</td>
<td>1.00</td>
</tr>
<tr>
<td>251-300</td>
<td>0.97</td>
</tr>
<tr>
<td>301-400</td>
<td>0.93</td>
</tr>
<tr>
<td>401-450</td>
<td>0.91</td>
</tr>
<tr>
<td>451 and above</td>
<td>0.87</td>
</tr>
</tbody>
</table>
Pipeline Construction Process

- DPP
- Land acquisition & Requisition
- Tender Document Preparation
- Tender
- Bid Evaluation
- Tender Award
- Procurement
- Mobilization
- Clearing, Grading and Stringing
Pipeline Construction Process (contd.)

- Welding and NDT
- Trenching, Lowering & Backfilling
- Tie-in
- Hydrostatic Testing
- Cleaning
- Commissioning
- Operation
Pre construction

- ROW Acquisition & Requisition
  - ROW Selection
  - DC Office
  - Compensation
  - Crop Compensation
Pre construction (Contd.)
General Guideline for Pipeline Routing

- Minimize overall pipe length.
- Parallel existing utility corridors (Highway, High tension Electric transmission line).
- Avoid areas of high population density.
- Minimize highways, railways, river, khals, canals, ponds, hills & mountains crossing to reduce the project cost.
- Cross highways, railways, river, khals, canals at or close to 90 deg. angle.
- Minimize crossover of existing facilities.
- Provide adequate construction area.
Pre construction (Contd.)
General Guideline for Pipeline Routing

- Avoid the following areas:
  - Swamps and Wetlands
  - Rocky areas
  - Unstable soil
  - Populated areas
  - Historical areas
  - Environmentally sensitive areas (Forest, Tea garden, Rubber garden etc.)
  - Religious sensitive areas (Mosque, Graveyard, temple etc.)
Pre construction (Contd.)

Land acquisition / Requisition:

- Normally 10 m wide strip along the proposed pipeline route is to be acquisition and a 15 m wide strip on one side of the acquisition strip is to be requisition.
- Acquisition is permanent possession for use of land but requisition is completely a temporary affair, only for the working period.
- For scraper station and Valve station separate block lands of required size have to be acquisition.
Pre construction (Contd.)

Submission of proposal for land acquisition & requisition:

- The company submit the proposal with requisite no. of drawings (Normally mouza map) showing acquisition & requisition strip in two distinct colors (red for acquisition & green for requisition) to DC office.
- The process of acquisition & requisition in our country is done through the DC office of the particular district.
- The whole process continues in accordance with Ordinance, Acts, Rules & Regulations issued by the government from time to time.
Pre construction (contd.)

- Tender
  - Floating
  - Bid Receiving & Evaluation
  - Contract Award & Contract Management
- Procurement
- Mobilization
Major steps for pipeline Construction

- Cleaning & Grading the ROW
- Stringing the pipe along ROW
- Welding the pipe joints together
- NDT of welding joints
- Coating & Wrapping
- Ditching / Trenching
- Holiday test
- Lowering & backfilling
- Pigging
- Hydro Test
- Commissioning
Equipment used for Pipeline Construction:

- **Bulldozer**: Used to clearing & grading of ROW.
- **Excavator**: Used to trenching, pipe lifting, pulling the welding machine etc.
- **Side boom**: Used to lift the pipe during welding and lay the pipeline in the trench.
- **Crane**: Used to handle heavy equipments and machineries.
- **Welding generator**
- **Trailer/ Truck**: Used to carry the line pipe from store yard to the working site.
Pipeline construction Equipment

- Excavator
- Side boom
ROW Clearing & Grading

- ROW is cleared of barriers and graded for movement of construction equipment, materials and ultimately construction of pipeline.
Pre Welding Activities

- **Welders test** - an exam for the welders before going to production weld.
- **Selection Criterion** - Visual inspection & NDT (API 1104)
- **PQR / WPS Test**
  - Tensile strength test
  - Face bend test
  - Root bend test
  - Charpy V notch test
Stringing

- Stringing is aligning the pipe along the ROW ready for welding.
- Trailer, Side boom etc are used to stringing the pipe.
Welding

- Root pass/ Stringer pass
- Hot pass
- Filling pass
- Cap Pass
- Cleaning the welds
NDT (Non Destructive Test)

- Dye penetrant test
- Magnetic Particle test
- Eddy current test
- Radiographic test
- Ultrasonic test
- NDT personnel certification (Level 1, 2 & 3)
NDT (Non Destructive Test)

- Radiography Test
  - Equipment
  - Method
  - Source
  - Film examination as Per API 1104 Standard
NDT (Non Destructive Test)

- Ultrasonic Test
  - Equipment
  - Method
  - Source
  - Weld examination
Common welding defects

- Porosity
- Cluster porosity
- Slag inclusion
- Lack of fusion
- Lack of penetration
- Internal concavity
- Burn through
- Crack
Welding defects:
Welding defects:

**Figure 14**—Inadequate Penetration Due to High-Low (IPD)

**Figure 15**—Inadequate Cross Penetration (ICP)

**Figure 16**—Incomplete Fusion at Root of Bead or Top of Joint

Note: The cold lap shown is not surface-connected.
Tie-in welds

- The final weld to join two separate section together.
- Should be properly aligned without use of jacks or any external force.
- Should be done within operating temp (5-30 deg. Celsius).
- NDT test.
Roads and Railway Crossing

Two different ways

- **Thrust boring/ Horizontal boring method**
  - Drill a hole under the roadway without disturbing the road/ rail surface.
  - A casing pipe is placed through the hole and then the pipeline is placed inside the casing.
  - Spacer is used to center the pipeline within the casing pipe.

- **Open Cut method**
Pipe Coating

- All except a portion (about 6 inch) of each pipe is often coated in the factory before deliver to the site.

- Three types of coating
  - 3LPE coating
  - FBE coating
  - Polyethylene coating

- 3LPE coating
  - Apply adhesive on clean pipe surface
  - Epoxy paint (40-100 micron)
  - Polyethylene coating
Bare pipe

Steel Pipe without coating
3 LPE Coated Pipe

- Features:
  - Cleaning (sand Blasting)
  - Apply Adhesive
  - Apply epoxy paint (40-100 micron thick)
  - Polyethylene coating
Concrete Coated Pipe

- Features:
  - Apply 3LPE Coating
  - Set wire mesh above 3LPE Coating
  - Apply Concrete coating
  - Provide –Ve buoyancy force
  - Apply on ditch, canal, pond, khal, small river
Set-on-Weight

- Features:
  - Put on above 3LPE coated pipe
  - one on each pipe
  - Provide –Ve buoyancy force
  - Apply on marshy area
Joint coating

- **Heat shrink sleeves**
  - Approx. 14 inch length and dia larger than pipe dia.
  - Shrink on applying heat and fitted to the pipe.
Ditching, Holyday test, Lowering & Backfilling

- Ditching
- Holyday test
  - Apply 10 KV on coated pipe surface
  - Any coating defect will result an audible sound.
- Lowering
  - Lay pipeline on Trench of approx. 1.2 m depth
  - Put *Set-on-weight* on buried pipe for anti-buoyancy force
Testing:

- Brush / cup pig
  - Clean internal rust
- Gauge pig
  - To check pipe ovality
- Foam Pig
  - To dry internal surface
Pig Receiver

- To receive pig at the terminal point
Pig Traps

Pig Receiver connected with pipeline
Hydro test

- After mechanical completion of pipeline
- Min test pressure should be 1.5 times of design pressure.
- Conventional hydro test pressure for high pressure pipeline = 1.5 × 1135 psi = 1703 psi
- Before commencing pressurization need to obtain necessary permission from the competent authority. As per Gas Safety rules Department of explosive is the competent authority in Bangladesh.
- Prior notification of testing should be given, in writing to persons in the vicinity of the pipeline.
Hydro test (contd.)

- Prior notification of testing should be given to local police and other authorities, who may be affected.
- Warning notice stating “Warning-PipeLine Under Test” and “No Parking” should be placed at appropriate locations for the duration of the test.
- Patrols should be provided to watch special points of hazard during the test, in particular road, rail and water crossing and points of public access.
- Standby emergency crew should be available to deal with any unwanted situation.
Prior to the commissioning the pipeline should be dry up.

Methods available for drying up are:
- Using dry air (compressor) push a series of foam pigs through the pipeline collecting water until the required dryness is achieved.
- The pipeline should be purged of before the admission of the gas to be transmitted.
- Use inert gas to purge of air.
- After drying up a pipeline can be commissioned straight to gas.
Codes and Standards

- ASME B31.8 (Onshore & Offshore)
- ASME B16.5 (Flange & Flange Fittings)
- ASME B16.21 (Gaskets for Flanges)
- API 5L (Line Pipe)
- API 6D (Valves)
- API 1104 (Welding Inspection)
- ASME U-Stamp (Pig Traps & Launcher)
- ASME Boiler & Pressure Vessel Code (Scrubber, KOD and Other pressure Vessels)