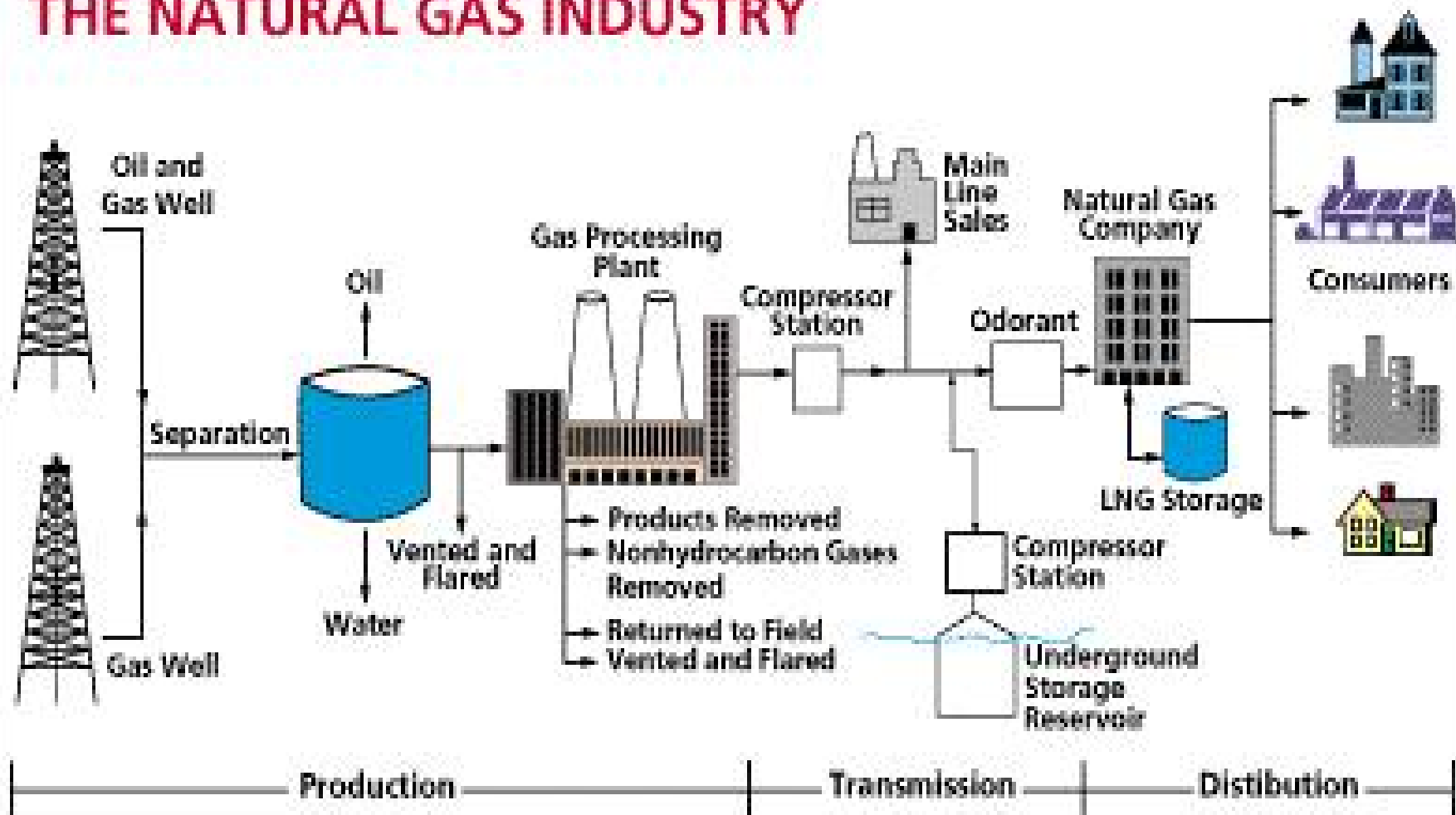


Gas Transmission System

**Design & Material
Selection**

Natural Gas Value Chain

THE NATURAL GAS INDUSTRY



Transmission System

- Transmission system : Midstream Activity
- Commences from a downstream flange of custody transfer metering stations (fiscal metering stations) of the gas production system - terminates at the custody transfer meters of the local distribution system.

Pipeline Quality Gas

- As Custody Transfer point from the production facility the ownership of Standard Pipeline quality gas is transferred from upstream production companies to mid stream transmission pipeline operator .
- The standard quality of pipeline gas is monitored and online chromatographs records the gas composition and heating value. Pipelines usually do not accept off spec gas as the pipelines are designed to handle spec gas

Pipeline Quality Gas

Characterstics & Components	Limit	
Wobbe Index	Minimum /Maximum	46.6 / 52 MJ per cubic meter
Carbon Dioxide	Maximum	3.0 mole %
Oxygen	Maximum	0.2%
Hydrogen Sulfide	Maximum	5.7 mg per cubic meter
Total Sulfur	Maximum	50 mg per cubic meter
Water Content	Maximum	Dew point 0°C at the highest MAOP in the relevant transmission system (in any case, no more than 112.0 mg/m3)
Hydrocarbon Dew Point	Maximum	10 degrees Celsius between the pressures of 1000 kPag and 10,000 kPag
Total Inert Gas	Maximum	7 mol %

Transmission System

- A transmission system comprises of
 - gas transmission pipelines, compressors stations, mixing stations and custody transfer metering stations along the pipelines and terminals
 - Supervisory Control and Data Acquisition (SCADA)
 - The pipelines may be a common carrier (open access) or a contract carrier (merchant pipeline)

Design Basics

- The following aspects of pipeline design, construction and operation shall be considered in the design of a pipeline:
 - Safety of pipeline and the public is paramount
 - Design should be specific to nominated fluid (gas, oil, water, etc.).
 - Route selection must consider the existing and planned land use and environmental needs.

Design Basics

- Considerations(continued):
 - The fitness of the design for the purposes of the pipeline and other associated equipment.
 - Engineering calculations for known load cases and probable conditions (weather, seismic).
 - Stress, strains, displacements, and deflection limits of materials.
 - Materials for pressure containment are required to meet standards and be traceable.
 - Fracture control plan to limit fast fractures is required.

Standard Design Code Of Gas Transmission System

- **ASME 831.8-2003 (Revision 01 ASME 831.8-1999)**
- **ASME CODE FOR PRESSURE PIPING, 831**
- **802.11** This Code covers the design, fabrication, installation, inspection and testing of pipeline facilities
- used for the transportation of gas. This Code also covers safety aspects of the operation and maintenance of those
- facilities.
- safety aspects of the operation and maintenance of those
- facilities.

ASME B 31.8

- The Code sets forth engineering requirements deemed necessary
- for the safe design and construction of pressure piping
- Although safety is the basic consideration,
- this factor alone will not necessarily govern the final specifications of any piping system.

ASME B31.8 : Continued

- To the greatest possible extent, Code requirements for
- design are stated in terms of basic design principles and formulas.
- These are supplemented as necessary with specific requirements to ensure uniform application of principles and to guide selection and application of piping elements

ASME B31.8 Continued

- This Code Section includes
 - (a)* references to acceptable material specifications and component standards, including dimensional and mechanical property requirements
 - (b)* requirements for designing components and assemblies

ASME B31.8 Continued

(c) requirements and data for evaluating and limiting stresses, reactions, and movements associated with pressure, temperature changes, and other forces

(d) guidance and limitations on selecting and applying materials, components, and joining methods

(e) requirements for fabricating, assembling, and installing piping

ASME B31.8

- *e)* requirements for fabricating, assembling, and installing piping
- *(f)* requirements for examining, inspecting, and testing piping
- *(g)* procedures for operation and maintenance that are essential to public safety
- *(h)* provisions for protecting pipelines from external and internal corrosion

Design Basics

- Preliminary Tests to meet conditions:
 - Pressure must be positively controlled and limited.
 - Pipeline integrity testing is planned for implementation before commissioning of pipeline.
 - For natural gas pipelines, the likelihood, extent and consequences of the formation of condensates and hydrates in the pipeline is established.
 - Prevention or mitigation measures are planned to be put in place to ensure safe operation and integrity of the pipeline.

Design Steps

- Select the right of way (ROW).
- Pipeline surveyors identify the shortest possible route with the least barriers and impediments from topography maps.
- Topography and terrain conditions, difficult crossings and soil conditions, accesses for construction and operation of the system must be taken into account.

Design Steps

- Optional routes are identified, and detailed environmental impact assessments (EIA), social impact assessments (SIA) and risk analysis[RA] are conducted to finally select the optimum ROW.
- At this stage, the following information is obtained from gas fields about supply conditions:
 - Maximum volume of gas that requires to be transported
 - Maximum pressure that the pipeline has to be operated
 - Temperature and quality of gas to be transported
 - Minimum pressure required at destinations

Design Basics

- ANSI B31.8 is a widely used design classification for transmission pipelines which allows maximum allowable operating pressure[MAOP] of 1440 PSIA (98 atm).
- The above classification dictates the line pipes and fittings which will be used for the pipeline.
- All gas transmission pipelines must be buried underground unless unavoidable. Main line valve stations and scarpers stations are often above ground.

Design Basics

- Transmission pipelines link the production system to the end users.
- Transmission pipelines can be built from offshore, onshore through deserts, forests, across hills, through aggressive terrains and water logged areas.
- Transmission systems can be built across country borders.

Design Basics

- Modified Panhandle Equation is used in computer software to design the transmission pipeline.

- $Q = 0.00123 (d_i)^{2.53} [p_1^2 - p_2^2 / L]^{0.51}$

Q = PIPELINE Capacity in MMCFD

d_i = Line pipe internal diameter in inches

P1= Maximum pressure at delivery point from gas field in PSIA

P2=Minimum pressure at receipt point of distribution system in PSIA

L = Length of the pipeline in miles

Design Basics

- After determining pipeline size and ROW, a detailed route survey is carried out to identify the requirements of special points (road, river, waterway, rail track and special section crossings).
- A soil survey is performed to ascertain the requirements for buoyancy control and the nature of cathodic protection for corrosion control.

Materials Selection: Line Pipe

- Line pipes: carbon/carbon manganese steel pipe, API spec 5L, ISO 3183, ASTM A53, ASTM A106 and ASTM A 524.
- There are minimum requirements for pipes complying with any of these standards
 - Pipe for use in accordance with these standards shall not have an Specified Minimum Yield Stress (SMYS) greater than 555 Mpa (X80).

Materials Selection: Line Pipe

- The integrity of any seam weld shall be demonstrated by non-destructive examination of the full length of the seam weld.
- The integrity of the line pipes shall be demonstrated by hydrostatic testing as part of the manufacturing process.
- Furnace welded pipe/ cast iron (CI) shall not be used for pressure containment.

Materials Selection: Line Pipe

Standards Used for Pipeline Components

- **Corrosion Resistant Alloys (for sour gas service):** API SPEC 5LC and API 5LD
- **Fiber glass:** API SPEC 15LR ,API 15HR,or ISO 14692 -1 and ISO 14692-2
- **Pipeline Assemblies:** Elements of a pipelines are assembled from pipe that complies with a nominated standard and pressure
- **Station Piping:** AS 4041,ASME B31.3

Materials Selection- Valves, Bends and Fittings

- **Valves:** ASME B 16.34, API Spec 6D , API Std 600, API Std 603, ASTM A 350, BS 5351, MSS SP -25, MSS SP -67.
- **Induction Bends:** ISO 15590-1, ASME B16.49
- **Flanges:** ASME B 16.5, ASME B 16.21, ANSI B 16.47 ,MSS SP-6,MSS SP-44
- **Gaskets:** ASME B 16.21 ,BS 3381.
- **Bolting:** AS2528, ANSI B18.2.1 ,ASME B16.5, ASTM A 193, ASTM A 194, ASTM A 307 , ASTM A 320, ASTM A 325, ASTM A 354 , ASTM A 449

Material Selection

- After the preliminary design is complete, the next step is to select materials and determine specifications.
- The materials required are:
 - Line pipe (mild steel line pipes)
 - Anti-corrosion coating materials
 - Bend
 - Valves, flanges and fittings
 - Pig launchers and receivers
 - Cathodic protection materials

Determination of Pipe thickness

- The following equation applies for determining pipe thickness.

$$t = fPR / S$$

Where

t=thickness of the pipe

f=factor of safety (usually 0.6)

P=internal pressure the pipe has to sustain

R=mean radius of the pipe

S= Specified Minimum Yield Stress (SMYS) of the pipe

Pipe Coating

- Line pipes are hollow cylinders.
- When buried underground in the presence of subsurface water, pipes can tend to float due to buoyancy effect.
- To counteract buoyancy, pipelines can be:
 - coated in concrete after application of anticorrosive coating or
 - weighted with concrete saddle weights after burial.

Pipe Coating



Formula for Calculating Buoyancy Control

- For uncoated pipe:

$$(B) = D/3[D-32t] + 11t^2$$

- For coated pipe:

$$(B) = E/3 (D-32t) + T_1 D [63 - W_c/48]$$

- Where:
- D=outside diameter of pipe, in.
- T=wall thickness of pipe, in
- T_1 =thickness of concrete coating, in.
- W_c =weight of concrete, lb/ft³

Bends

- Pipelines are not straight. To fit into pipeline profile bends are used wherever required .
- 5 D bends of standard angles are fabricated from the same steel as used in pipe in the factory. These are known as fire bends/ hot bends . These are of 12 ½ , 15, 25, 30, 45 , 60 and 90 degrees.
- If other bends are required, these are fabricated at pipeline construction sites . These are called field bends.

Lowering of Welded pipeline with Bend



Valves

- As a safety measure, during operation of long distance transmission pipelines, line break valves are installed at prescribed intervals.
- These valves are located at places which have easy access facilitating required routine and emergency maintenance.
- Valve stations are usually above ground and have manual and remote operation facilities.

Valves

- Main line valves have bypass and blow down facilities.
- Remote control valves have line break facilities and are filled with gas over oil actuators.
- Command of the valves from the SCADA control center is conveyed through Remote Terminal Units (RTUs).
- Transmission systems use API 6D top entry/ side entry welded body/ forged body double block and bleed line valves.
- Tees, elbows, flanges and fillings follow ANSI #600 standard.

Scraper Stations

- Every transmission pipeline must have scraper launcher and receiver stations at either end. For a long distance pipeline, such stations are set up after every 90-100 KM.
- Scrapers are used for swabbing, cleaning, gauging, hydrostatic testing of pipelines.
- Scraper stations are also used for routine on-stream scraping and metal loss surveys (intelligent scraping) of the pipeline.

Standard Codes For Construction Welding

- Welding is the major activity of pipeline construction .
- Transmission pipelines unless unavoidable is buried underground at prescribed cover
- All pipe joints are welded following API 1104 or equivalent welding codes .
- All welds are 100% radiographed by X Ray /Gamma Ray or Automatic Ultrasonic Method.

Pipe Coating

- Mild steel pipes require anti corrosion coating
- NACE Standard is followed for coating .
- Coal Tar Enamel Coating , Fusion Bonded Epoxy Coating , PE (double layer of 3 Layer) , Yellow Jacket are standard coating methods.
- In swampy areas for buoyancy control Concrete coating / Saddle Weights / Mechanical Anchors are used as required

Special Points

- Roads , Rail , Rivers , Waterways , Swampy Areas , Valve Stations , Scarper Stations are Special points are Vulnerable points .
- Special Construction Procedures apply in their construction .
- These are constructed by special crew and tied to the main line after construction .
- These special points come under patrolling and vigilance during operation of the pipeline .

Cleaning ,Swabbing and Gauging

- Constructed sections of the pipelines are cleaned , swabbed and gauged by driving pigs with compressed air
- Cleaning takes up most of the undesirable elements that may have entered the pipelines during construction
- Swabbing mops out moisture and water
- Gauging maps the internal diameter of the pipeline

Hydro testing & Commissioning

- Cleaned and gauged pipeline is filled with water having pH value of 7.0 and free of corrosive materials.
- Compact filling is done to remove air and pipe is pressurized to about 1.44 times of the maximum allowable operating pressure.
- During this process, the tightness test is carried out to detect leaks.
- For strength tests, the pressure is held in line for 24 hours and monitored through installation of three-pen chart recorder.

Quality Control

- Strict quality control and quality assurance must be ensured at every stage of pipeline construction.
- A poorly constructed pipeline will create nightmare for the pipeline operator.
- All as-built documentations must be properly recorded and made readily available for operator to make required operation and maintenance plans.