Introduction to Gas Pipeline Design and Construction

Marco D. Boscardin, Ph.D., P.E., LSP
Boscardin Consulting Engineers, Inc.
Outline of Presentation

I. Introduction
II. Typical Gas Pipeline Design Considerations
III. Typical Gas Pipeline Construction Methods
IV. Potential Landowner Concerns
V. Potential Impacts
VI. Closing
VII. Questions
Pipeline Conditions in Massachusetts

Map of Massachusetts showing various cities and towns, rivers, and geographical features. The map includes major cities such as Boston, Worcester, and Springfield. The map is sourced from www.worldatlas.com.
Potential Conditions Along A Pipeline Route in Massachusetts

- Sand, Clay, Glacial Till, Shallow Rock, Slopes
- Streams and Wetlands
- Roads and Railroads
- Conservation Areas
- Agricultural Lands
- Cultural Resources
- Cities, Towns, Rural Residences
Potential Issues for Landowner and Community

- Alignment Selection
- Safety
  - Explosion
  - Toxicity
- Impacts on Surrounding Land Use and Facilities
  - Future ROW use, Restored Soil Fertility, Routine Access
- Erosion Control, Noise, Dust, Vibration, Releases
  - Construction vs. O & M, Herbicides
- Crossing Sensitive Lands
Gas Pipeline Design Considerations

- Function - Transmission vs. Distribution

- Transmission Line: Typ. Size – 24-to-40-inch-diameter pipe; Pressure – to 1500 psi

- Design Life (50 to 75 years) vs Actual (potentially much more)

- Loads – Soil, Water, Thermal, Surcharges, Seismic, Ground Stability
Design Considerations - a

- Alignment Corridor Access Constraints

- Ground, Environmental, Cultural, Population, Societal Use

- Corrosion, Abrasion, Chemical & Electrical Attack

- Pipe Material
  - Steel for Larger, Higher Pressure Lines (SMYS = 70,000 psi Grade X-70 Steel Strength)
### Location Class per 49 CFR 192

<table>
<thead>
<tr>
<th>No. houses per mile</th>
<th>Class Location</th>
<th>Stress Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 or less</td>
<td>1</td>
<td>72%</td>
</tr>
<tr>
<td>10 to 46</td>
<td>2</td>
<td>60%</td>
</tr>
<tr>
<td>46 or more</td>
<td>3</td>
<td>50%</td>
</tr>
<tr>
<td>4-story buildings</td>
<td>4</td>
<td>40%</td>
</tr>
</tbody>
</table>

**Other Class 4 - High Consequence Area - Schools/Hospitals/Lifeline Facilities, Outside Assembly Areas**

From: George W. White | Pipeline & Gas Journal September 2012, Vol. 239 No. 9
Gas Pipeline Construction Methods

- Conventional Trenched Construction on Land
  - Cut-and-Cover
    - For a 36-inch Pipe Expect at Least a 5-Foot wide Trench, Possibly more if sloped.
  - Trenching Machines
    - Typically 85-to-100-foot-Wide Construction Easements, 50-foot Permanent ROW
Pipeline Construction Sequence

From the Federal Energy Regulatory Commission
Clearing ROW

From www.pipeliners-uk.com
Stringing Out Pipe

From Pacific Connector Gas Pipeline
(www.pacificconnectorgp.com)

From Plymouth HDD (2004)
Trench Excavation

From Pacific Connector Gas Pipeline
(www.pacificconnectorgp.com)

From Hamle
(www.hamleas.com)
Installing Pipe

From PBS Newshour
(www.pbs.org)

From Natural Gas Asia
(www.naturalgasasia.com)
Restoration
Pipeline Construction Methods - a

- **Pipe Assembly**
  - Welding Pipe – QA/QC
  - Corrosion Coating at Joints, Coating Repairs
  - Handling and Installing Pipe Damage to Pipe, Welds and Coatings

- **QA/QC**
  - Key to Success and Long-Term Performance
  - Inspection, Testing
Coated Pipe Arrives at Site

From NCPR
(northcountrypublicradio.com)
Welding – Manual & Mechanized

From Miller
(www.millerwelds.com)

From Gasprom
(www.gasprom.com)

From INGAA Foundation Report 2013.01
Welding

From Pacific Connector Gas Pipeline
(www.pacificconnectorgp.com)
Field Coating Welds

From North American Oil and Gas Pipelines
(www.napipelines.com)
Pipeline Construction Methods - b

- Trenchless to Pass Under Areas with Less Disturbance
  - Pipe Jacking, Microtunneling, Horizontal Directional Drilling (HDD)

- Underwater Construction
  - Similar Methods as On Land Plus Plowing
  - Environmental Management More Challenging
  - Ballasted to Prevent Floating, Scour Protection, Future Dredging
Microtunneling Machine - MTBM

From Herrenknecht
(www.herrenknecht.com)

MACHINE INTRODUCED TO JACKING PIT
Horizontal Directional Drilling (HDD)
Horizontal Directional Drilling (HDD)

From www.pipeliners-uk.com

From Plymouth HDD (2004)
HDD Start of Pullback with Reamer Head

From alibaba.com

From www.pipeliners-uk.com
HDD End of Pullback at Exit Pit

From Accurate HD (www.accuratehd.com)

From Trenchless Technology (trenchlessonline.com)
Pulling Pipe Through a Casing
Pipe Pulled into Casing Installed Via Trenchless Methods In Sensitive Area

From Kinnan Engineering, Inc.
(www.kinnanengineering.com)
Wetlands Construction Using Temporary Dams and Dewatering

From Burns McDonnell
(www.bumsmc.d.com)
Pipeline Construction Methods - c

- Difficult Ground
  - Very Hard Ground
  - Very Soft Ground
- Ground Water Inflows
- Unstable Ground – Slopes, Subsidence
Smart Pig to Inspect and Test Pipeline

Energy companies use a special pipeline inspection gauge, known as a smart pig, that contains electronic and magnetic sensors to check the interior condition of pipe walls. If they detect cracks or other problems, workers can further inspect sections of the pipeline, or dig it up for repairs or replacement. The pig is launched through traps off the main pipeline and propelled by the flowing oil.
Potential Landowner Concerns

- Right of Way Limitations
- Leaking Gas
- Noise, Dust and Emissions
  - During Construction
  - During Operation - Compressors
### TABLE 3.1-1 Patrol Frequency for Natural Gas Transmission Pipelines

| Characteristics of Area Consisting of 220 yards of 1-mile Length of Pipeline | Maximum Interval between Patrols |
|---|---|---|
| Any location having fewer than 46 buildings intended for human occupancy | At Highway and Railroad Crossings: 7.5 months; but at least twice each calendar year. | At All Other Places: 15 months; but at least once each calendar year. |
| Any location having 46 or more buildings intended for human occupancy or where the pipeline lies within 100 yards of a building | 4.5 months; but at least four times each calendar year. | 7.5 months; but at least twice each calendar year. |
| Any location where buildings with four or more stories above ground are prevalent | 4.5 months; but at least four times each calendar year. | 4.5 months; but at least four times each calendar year. |
Managing Water and Erosion

From Climate Progress (thinkprogress.org)
Potential Impacts

- Building or Utility Settlements
- Noise, Vibration
- Wells & Septic Systems
- Roadways
- Wetlands
## Construction Right of Way

### Table: R.O.W. Dimensions (Feet Except for Diameter, Which is Inches)

<table>
<thead>
<tr>
<th>Diameter</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
</tr>
</thead>
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<tr>
<td>12&quot;</td>
<td>40</td>
<td>5</td>
<td>30</td>
<td>25</td>
<td>50</td>
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<td>40</td>
<td>35</td>
<td>65</td>
<td>100</td>
<td>4</td>
</tr>
<tr>
<td>36&quot;</td>
<td>50</td>
<td>10</td>
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<td>42&quot;</td>
<td>60</td>
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<td>40</td>
<td>40</td>
<td>70</td>
<td>110</td>
<td>6</td>
</tr>
<tr>
<td>48&quot;</td>
<td>75</td>
<td>10</td>
<td>35</td>
<td>47.5</td>
<td>72.5</td>
<td>120</td>
<td>6</td>
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[From INGAA Foundation Report 2013.01](#)
Construction Right of Way on Slope

From INGAA Foundation Report 2013.01
Compressor Station

From Valdes Engineering Company
(www.valdeseng.com)

From LG&E KU
(http://lge-ku.com)
Questions?
(1) The pressure at the beginning of a pipeline and at each of the end points of a pipeline shall be monitored.

(2) The flow rate and other pressures or operating functions determined necessary by the operator for the safe operation of a pipeline shall be monitored.

(3) The functions listed in 220 CMR 109.13(1) and 109.13(2) shall be monitored at a continuously attended control center. Any abnormal condition of a monitored function shall activate audible and visible alarms at the control center.

(4) The entire route of the pipeline shall be patrolled at least four times each calendar year but at intervals of no more than 4 1/2 months.

(5) Each pipeline shall be leakage surveyed at least once each calendar year but at intervals of no more than 15 months. Leakage surveys shall be done with flame ionization detectors or equivalent devices.

(6) There shall be written procedures for any maintenance or repairs performed on a pipeline. The materials and equipment used for maintenance or repair shall be suitable for the MAOP of the pipeline. Personnel shall be trained in the procedures and use of the materials and equipment before any maintenance or repairs are performed.
O & M - Safety Precautions Include

- **Aerial Patrols** - To detect construction activities too close to the route of the pipeline, particularly in residential areas. Unauthorized construction and digging is a primary threat to pipeline safety.

- **Leak Detection** - Natural gas detecting equipment is periodically used to check for leaks at the surface.

- **Pipeline Markers** - Signs above natural gas pipelines to warn the public and reduce the chance of interference with the pipeline.

- **Gas Sampling** - Routine sampling of the natural gas in pipelines for quality, indications of corrosion of the interior of the pipeline, or the influx of contaminants.

- **Preventative Maintenance** - Testing of valves, removal of surface impediments to pipeline inspection.

- **Emergency Response** - Emergency response teams that train for the possibility of a wide range of potential accidents and emergencies.

- **DigSafe**
(Modified from Reactivation of Prethrusting...within the Ordovician Champlain-Taconic Thrust System, Hayman and Kidd, GSA, 2011)
Note:
1) This location for topsoil will be required if full width topsoil stripping is required.
1. TWO-TONE THE RIGHT-OF-WAY TO LIMIT THE NEED FOR DEEP CUTS AND ADDITIONAL RIGHT-OF-WAY ON STEEP SLOPES
2. CLEAR AND STAKE ADDITIONAL RIGHT-OF-WAY TO ALLOW FOR EXTRA SPOIL
3. ENSURE SIDE BOOM TRACTORS ARE EQUIPPED WITH BOOM EXTENDERS AND COUNTERWEIGHTS IF REQUIRED.
4. USE BACKHOE TO ASSIST BULLDOZERS WITH REPLACING CUTS.
5. EMPLOY EROSION CONTROL MEASURES SUCH AS BREAKERS, CROSS DITCHES AND BERMS, AND REVEGETATION.

FIGURE 2.2-7 Typical Two-Tone Construction ROW (Source: FERC 2006b)
MTBM Jacking Pipe into Place

From Akkerman Inc.
MTBM Receiving Pit

From Port Authority, North Shore Connector (ITE 2006)
Inserting a Pig to Inspect Pipeline

From Fluxys Belgium
(www.fluxys.com)
Reading Pipe for Assembly
### Location Class per 49 CFR 192

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**HIGH CONSEQUENCE AREA DEFINITION**

- A Class 3 or Class 4 location.

- An area in a Class 1 or Class 2 location where the potential impact radius is greater than 660 feet (220 yards) and the potential impact circle contains 20 or more buildings intended for human occupancy or an identified site.

- Areas Where Large Numbers of People Often Congregate

- **Potential Impact Radius (PIR)**
  - 930 feet for 36-inch pipe at 1400 psi

From PIPELINE INTEGRITY BASICS, Presented by Dr. John F. Kiefner, June 22, 2011
**Design Considerations - b**

- **QA/QC (During Manufacturing, Construction Operation)**
  - Standards
    - PHMSA, CFR, ASME, Welder Certification
  - Inspections
    - Visual, Smart Pigging
  - Testing
    - X-ray Welds, Hydrostatic Pressure Tests, Non-Destructive Testing

- **Operation & Maintenance**
  - Inspections, Patrols, Testing

- **Risk**
Gas Pipeline Design Considerations

- **Function - Transmission vs. Distribution**
  - Transmission – Bulk Transport, Larger-Higher Pressure Pipes, Few Connections
  - Compressor Stations to Periodically Boost Pressure due to Friction Losses
  - Distribution – Delivery to Customers – Many Smaller Pipes/Connections – 5 to 100 psi

- **Transmission Line**: Typ. Size – 24-to-40-inch-diameter pipe; Pressure – to 1500 psi
  - 2 x Diameter: Can Deliver More than 4 x the Volume of Gas
  - Higher Pressure Compresses Gas So Can Transfer More

- **Design Life (50 to 75 years) vs Actual (potentially much more)**

- **Loads – Soil, Water, Thermal, Surcharges, Seismic, Ground Stability**

- **Alignment Corridor Access Constraints**
Design Considerations - a

Ground, Environmental, Cultural, Societal Use
- Rock, Sand, vs. Clay and Ease of Construction
- Ecologically Sensitive Areas, Endangered Species, Cultural Lands
- Urban, Suburban, vs. Rural Lands
  - Class Location Based on Occupancy per Mile within 660 feet of the Pipe
  - High Consequence Area - Schools/Hospitals/Lifeline Facilities, Outside Assembly Areas

Corrosion, Abrasion, Chemical & Electrical Attack
- Coatings - Outside & Inside; Cathodic Protection; Pipe Wall Thickness
- Depth of Burial Minimum 3 feet to Top of Pipe (220 CMR 109), Deeper Under Roads, In Agricultural Areas, and More Populated Areas

Pipe Material
- Steel for Larger, Higher Pressure Lines (SMYS = 70,000 psi Grade X-70 Steel Strength)
- HDPE Could Be Used for Lower Pressure Lines (<100 psi Gas Pressure)
Pipeline Construction Methods - a

- Pipe Assembly
  - Welding Pipe – Comes in 40 to 60-Foot Lengths, Need to Connect
    - Manual, Mechanized, Certified Welders
  - Field Coating – Factory Coated with Fusion Bonded Epoxy or Extruded Polyethylene - At Least Outside and Perhaps Inside
  - Handling and Installing Pipe
    - Damage to Pipe, Welds and Coatings

- QA/QC
  - Key to the Success and Long-Term Performance of the Pipeline
  - Inspection, Testing

- Work Plans and Submittals Process
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- **Work Plans and Submittals Process**
Pipeline Construction Methods - c

- Difficult Ground
  - Very Hard Ground
    - Blasting, Expansive Grouts, Mechanical Breaking, Mechanical Cutting
  - Very Soft Ground
    - Presupport, Ground Modification

- Ground Water Inflows
- Unstable Ground – Slopes, Subsidence
Potential Landowner Concerns

- Right of Way Limitations
  - How Close to Structures - Min. Dist. = 40 feet, or Class 4 Construction (220 CMR 109)
  - Vegetation - Pipeline Company Will Cut to Maintain Access
  - Excavation - Restricted
  - Load Limits

- Leaking Gas
  - Health Effects - Primarily Methane
  - Diffusion Dissipates - Lighter than Air - Don’t Want to Trap - Want Barriers to Migration Along Trench
  - Explosion Potential

- Noise, Dust and Emissions
  - During Construction
  - During Operation - Compressors
Potential Impacts

- Building or Utility Settlements

- Noise, Vibration
  - Excavation, Truck Traffic, Compaction, Blasting, Mech. Exc. of Rock

- Effects on Wells

- Effects on Septic Systems

- Effects on Roadways

- Effects on Wetlands