

Introduction to Gas Pipeline Design and Construction

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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



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

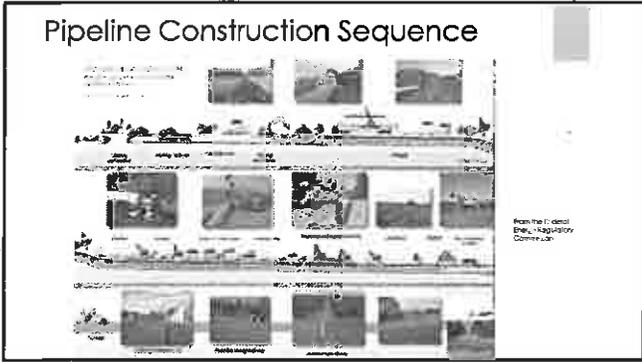
No. houses per mile	Class Location	Stress Level
10 or less	1	72%
10 to 16	2	60%
46 or more	3	50%
4-story buildings	4	40%

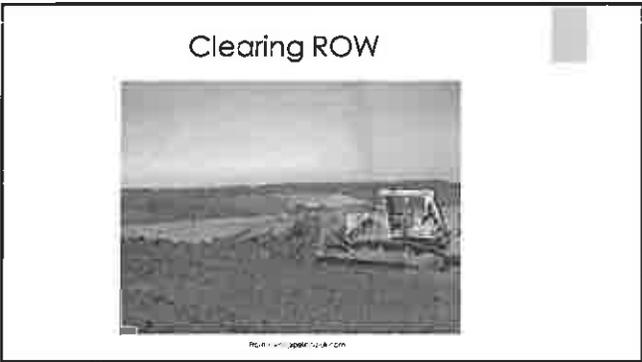
Other: Class 4-High Consequence Area - Schools/Hospitals/LifeLine Facilities, Outside Assembly Areas

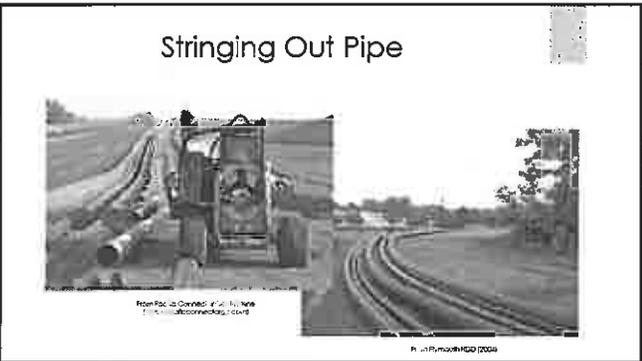
From: George W. White | Pipeline & Gas Journal September 2012, Vol. 239 No. 9

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







Trench Excavation



From Pacific Connector Gas Reserve
© 2010 Pacific Connector Gas Reserve



From YouTube
© 2014 YouTube

Installing Pipe



From YouTube
© 2014 YouTube



From YouTube
© 2014 YouTube

Backfilling



From YouTube
© 2014 YouTube

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



Welding – Manual & Mechanized



From NQA's Project 2013 Report

From NQA's Project 2013 Report

From NQA's Project 2013 Report

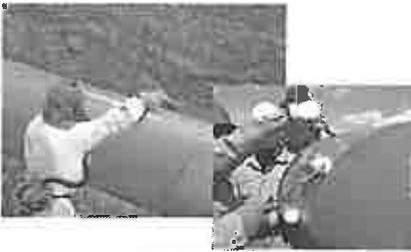
Welding



From NQA's Project 2013 Report

From NQA's Project 2013 Report

Field Coating Welds

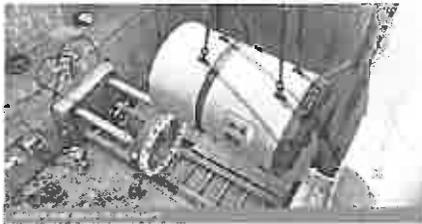


From NQA's Project 2013 Report

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



Horizontal Directional Drilling (HDD)



Horizontal Directional Drilling (HDD)



from www.enr.com



from www.hydro-hdd.com

HDD Start of Pullback with Reamer Head



from www.enr.com



from www.enr.com

HDD End of Pullback at Exit Pit



from www.enr.com



from www.enr.com

Pulling Pipe Through a Casing



From *Non-Destructive Testing, 2nd Edition*, by
Richard C. Fenner, Inc.

Pipe Pulled into Casing Installed Via Trenchless Methods In Sensitive Area



From *Non-Destructive Testing, 2nd Edition*, by
Richard C. Fenner, Inc.

Installing Pipe Underwater



From *Non-Destructive Testing, 2nd Edition*, by
Richard C. Fenner, Inc.

From *Non-Destructive Testing, 2nd Edition*, by
Richard C. Fenner, Inc.

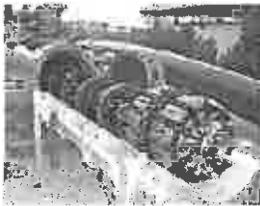
Wetlands Construction Using Temporary Dams and Dewatering



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



Potential Landowner Concerns

- ▶ Right of Way Limitations
- ▶ Leaking Gas
- ▶ Noise, Dust and Emissions
 - ▶ During Construction
 - ▶ During Operation - Compressors

Human Patrols to Inspect Pipeline Corridors

TABLE 3.4.4 Patrol Frequency for Natural Gas Transmission Pipelines

Patrol Frequency for Pipeline		
Category of Pipeline	Patrol Frequency	Notes
High-pressure gas transmission pipelines (operating at 100 psi or greater)	At least once per week	Patrols should be conducted at least once per week, and more frequently if necessary.
Medium-pressure gas transmission pipelines (operating at 100 psi or less)	At least once per month	Patrols should be conducted at least once per month, and more frequently if necessary.
Low-pressure gas transmission pipelines (operating at less than 100 psi)	At least once per year	Patrols should be conducted at least once per year, and more frequently if necessary.

Managing Water and Erosion

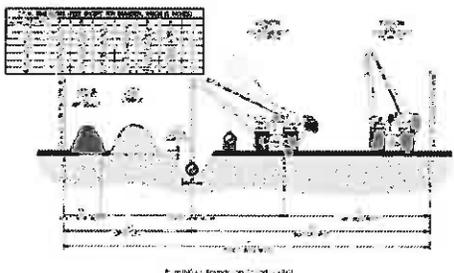


From Denver Pipeline Review Meeting

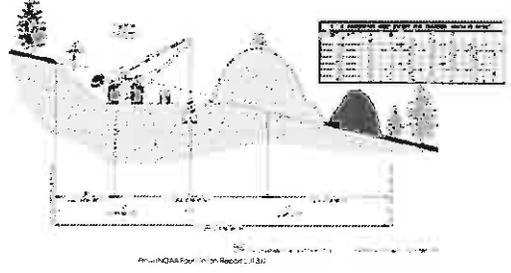
Potential Impacts

- ▶ Building or Utility Settlements
- ▶ Noise, Vibration
- ▶ Wells & Septic Systems
- ▶ Roadways
- ▶ Wetlands

Construction Right of Way



Construction Right of Way on Slope



Compressor Station



From: [Water Engineering Company](#)



From: [Water Engineering Company](#)

Valve



From: [Water Engineering Company](#)

Questions?

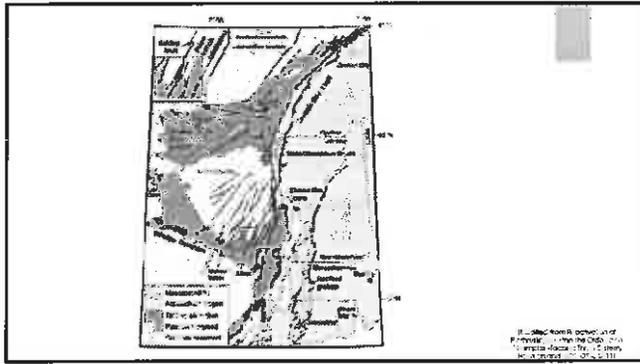


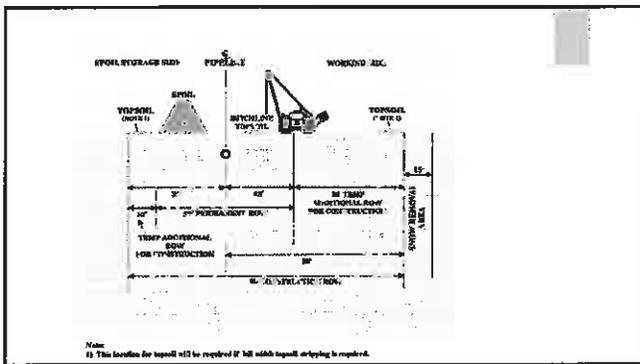
220 CMR 109.13

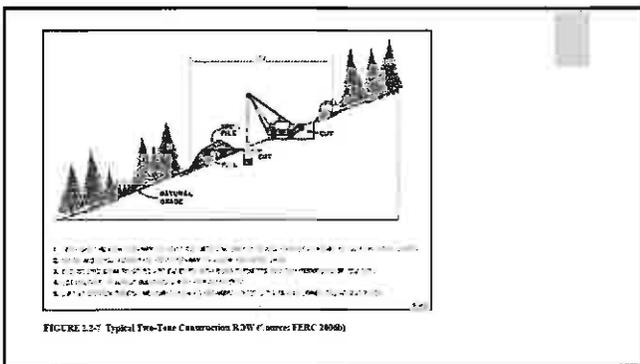
- ▶ (1) The pressure at the beginning of a pipeline and at each of the end points of a pipeline shall be monitored.
- ▶ (2) The flowrate and other pressures or operating functions determined necessary by the operator for the safe operation of a pipeline shall be monitored.
- ▶ (3) The functions listed 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.
- ▶ **Preventive 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**







1. Spoil Storage Bed
2. Pipeline
3. Working Bed
4. Topsoil
5. Temporary Storage Bed for Construction

FIGURE 1.2-7 Typical Pre-Tax Construction ROW (source: FERC 2006b)

MTBM Jacking Pipe into Place



From: [MTBM Jacking](#)

MTBM Receiving Pit



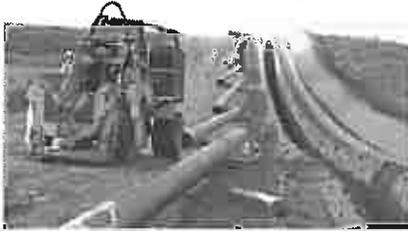
From: [Authority, North San Corridor 11/2/2014](#)

Inserting a Pig to Inspect Pipeline



From: [Pipeline Inspection](#)

Reading Pipe for Assembly



From: E (unreadable) .com/ma

Location Class per 49 CFR 192

No. houses per mile	Class Location	Stress Level
10 or less	1	72%
10 to 46	2	60%
46 or more	3	50%
4-story buildings	4	40%

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

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, Preselec / by Dr. John F. Klambauer, June 11, 2011

Design Considerations - b

- ▶ QA/QC (During Manufacturing, Construction Operation)
 - ▶ Standards
 - ▶ PHMSA, CFP, ASME, Welder Certification
 - ▶ Inspections
 - ▶ Visual, Smart Piggings
 - ▶ Testing
 - ▶ X-Rc, Welds, Hydraulic 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, Fewer 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
 - ▶ 2x 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 Constrains

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
 - ▶ Gas Location Based on Occupancy per Mile within 60 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 (S115 = 70,000 psi Grade's 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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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 Dispersals – 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
