



# **CO<sub>2</sub> Pipelines**

## **New Technologies & Economics for Carbon Capture / Sequestration**

*March 29, 2019*

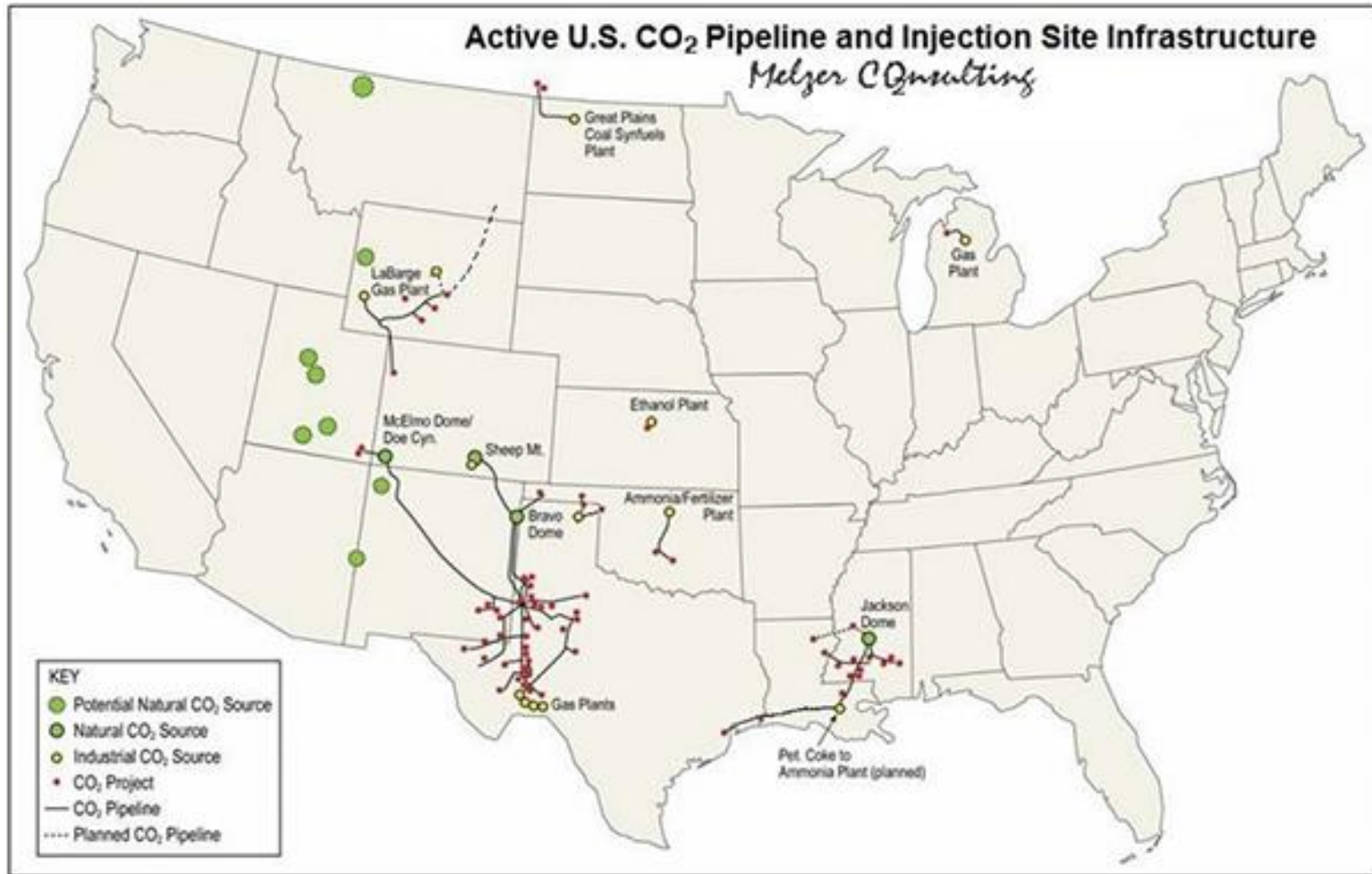
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Kinder Morgan CO<sub>2</sub> Company

**KINDER  MORGAN**

# CO<sub>2</sub> Pipelines in the US

*Safest and cheapest transport method for major volumes*

Roughly 5,000 miles total in the US, starting in 1972



# CO<sub>2</sub> Pipelines vs. Natural Gas Pipelines

- Use same steel metallurgy as Natural Gas Pipelines
  - Keep CO<sub>2</sub> dry
- Higher operating pressures
  - Gas – 600 psig to 1200 psig
  - CO<sub>2</sub> – 2000 to 3000 psig
  - Why? Maintain CO<sub>2</sub> in dense phase (>1300 psig) to allow pumping rather than compression. Also allows for smaller pipe diameters.
- Pumps rather than compression
  - Energy savings
- CO<sub>2</sub> - PHMSA regulated under CFR Part 195, “Transportation of Hazardous Liquids by Pipeline”
- Natural Gas – PHMSA regulated under CFR Part 192, “Transportation of Natural and Other Gas by Pipeline”
- Both CO<sub>2</sub> and Natural Gas Pipelines are required to have manned, 24 hour monitoring and control facilities

# Current Kinder Morgan CO<sub>2</sub> Pipeline Specifications



## Quality specifications for CO<sub>2</sub> pipelines.

- a) Product. Contain at least 95 mole percentage of CO<sub>2</sub>.
- b) Water. Contain no free water, and not more than thirty (30) pounds of water per mmcf in the vapor phase.
- c) Hydrogen Sulfide. Contain no more than 20 ppm, by volume, of H<sub>2</sub>S.
- d) Total Sulfur. Contain no more than 35 ppm, by weight,
- e) Temperature. Shall not exceed 120°F.
- f) Nitrogen. Contain no more than 4 mole percent.
- g) Hydrocarbons. Contain no more than 5% mole percent and Dew point no more than -20°F.
- h) Oxygen. Contain no more than 10 ppm, by weight, of oxygen.
- i) Other. Contain no liquid glycol or no more than 0.3 gallons of glycol per MMcf.

## Why are these specifications important?

- a) Product. Maintain dense phase
- b) Water. Free water causes corrosion and damages pump seals.
- c) Hydrogen Sulfide. Corrosion concern and dangerous to health and safety of the public. Special requirements if > 99 ppm in Texas.
- d) Total Sulfur. Foul odor in product
- e) Temperature. Protect pipeline external coating
- f) Nitrogen. Maintain dense phase of product
- g) Hydrocarbons. Maintain dense phase of product and EOR performance characteristics
- h) Oxygen. Catalyst for other internal corrosion components. H<sub>2</sub>S and O<sub>2</sub> form elemental sulfur in EOR piping
- i) Other. Glycol damages pump seals.

# CO<sub>2</sub> Pipelines-Operations

## Operations:

- ANSI 900/1,500 Pipeline System
- Minimum CO<sub>2</sub> Pressure: 1,300 psig
- Maximum Operating Pressure (MOP) varies per hydraulics/terrain
  - Typical: 2,160 psig / 2,220 psi
  - As high as 3,000+ psig
- Measurement – Orifice Measurement
- Cathodic Protection
  - Typical: Impressed Current System
- Remote Controlled by SCADA
- Pipeline Integrity Program
  - “Piggable”-Pigging program per CFR 195 and Kinder Morgan O&M
  - Anomaly Digs Per CFR 195 & O&M
- One Call Program
  - 811 Call Before You Dig Program



**Know what's below.  
Call before you dig.**

- **None exists today**
- **Challenges to economical development are many**
  - **Conversion of an existing pipeline is unlikely**
    - Low pressure rating
    - Compression costs higher than pumping costs
    - If ROW is more recent, likely to have service restrictions
  - **Use of existing ROW could be difficult**
    - More recent ROW agreements are often limited to one pipeline
    - Potential service restrictions
  - **Costs are higher than in other basins**
    - ROW
    - Construction (terrain)
  - **Prefer a gathering system collecting major volumes**
    - Reduces per unit transportation costs
    - Diversity of supply increases supply reliability

**QUESTIONS?**

# Kinder Morgan CO<sub>2</sub> Pipeline System

Longest CO<sub>2</sub> pipeline system out of the roughly 5,000 miles total in the US

## CO<sub>2</sub> Pipeline System



## Pipeline Details

Name	Length (miles)	Diameter	Year Built
CRC PL	138	16"	1972
Cortez PL	502	30"	1984
Central Basin PL	143	26", 24", 20", & 16"	1985
Pecos PL	25	8"	1985
Centerline PL	112	16"	2002
Cogdell PL	4	10"	2003
Eastern Shelf PL	91	10"	2010
Tall Cotton PL	6	12"	2014
<b>Total</b>	<b>1,304</b>	<b>4" to 30"</b>	



# CO<sub>2</sub> Pipelines - Regulations

- Regulated by Department of Transportation, Pipeline Hazardous Materials Safety Administration
- CO<sub>2</sub> Pipelines are regulated under 49 CFR 195 - Transportation of Hazardous Liquids by Pipeline
- Governs materials, design, construction, operations, and maintenance
- State Agencies may have additional regulations
- Regulations are specific/prescriptive or performance based
- Operations and Maintenance Manual
  - Operator interpretation and implementation of code
  - Provides uniform standard
  - Auditable procedures
  - Must follow plans and procedures as outlined in O&M Manual
  - Operators must comply with minimum standards from code or state
- Records prove compliance – types of records
  - Life of facility (includes construction, materials, repairs, testing, and MOP information)
  - Transient (includes tests, inspections, patrols, and surveys)
  - No records = did not do the work
- Pipeline Safety Management System – API RP 1173

# CO<sub>2</sub> Pipelines – Operations

SCADA: Operational Control

## Cortez, Colorado Control Center



## System Control

- 24 hour monitoring and control of Pipeline Facilities
- Monitor pressures and flow at key points on the system
- Receive key alarms from field locations and callout employees in response
- Provides full remote control to:
  - Start/stop Pump Stations
  - Flow control of meter facilities to customers
  - Shut-down and closure of valves during normal operations and in an emergency

# CO<sub>2</sub> Pipelines - Design

Engineering/Design

## Engineering/Design

- Hydraulics
- CO<sub>2</sub> Quality
- H<sub>2</sub>S
- Outside Diameter
- Wall Thickness
  - Barlow's Formula
  - Standard/Heavy Wall
- Ductile Fracture Analysis
  - Theoretical Charpy Numbers
  - Crack Arrestors
    - Operating Company risk tolerance
    - Design pipeline system in order to not add fracture arrestors
    - Wall thickness changes (crossings) to act like fracture arrestors

## Lot Purchases from Vendor

- Review MTR's in detail before purchase
  - High Grade/High Strength
  - Approved Vendors/mills



# CO<sub>2</sub> Pipelines-Pipe

*Engineering/Design/Specification*

## Reference

- API Specification 5L; “Specification for Line Pipe” (45<sup>th</sup> Ed). PSL 2 Product Specification Level

## Pipe Manufacturing Process and Grade:

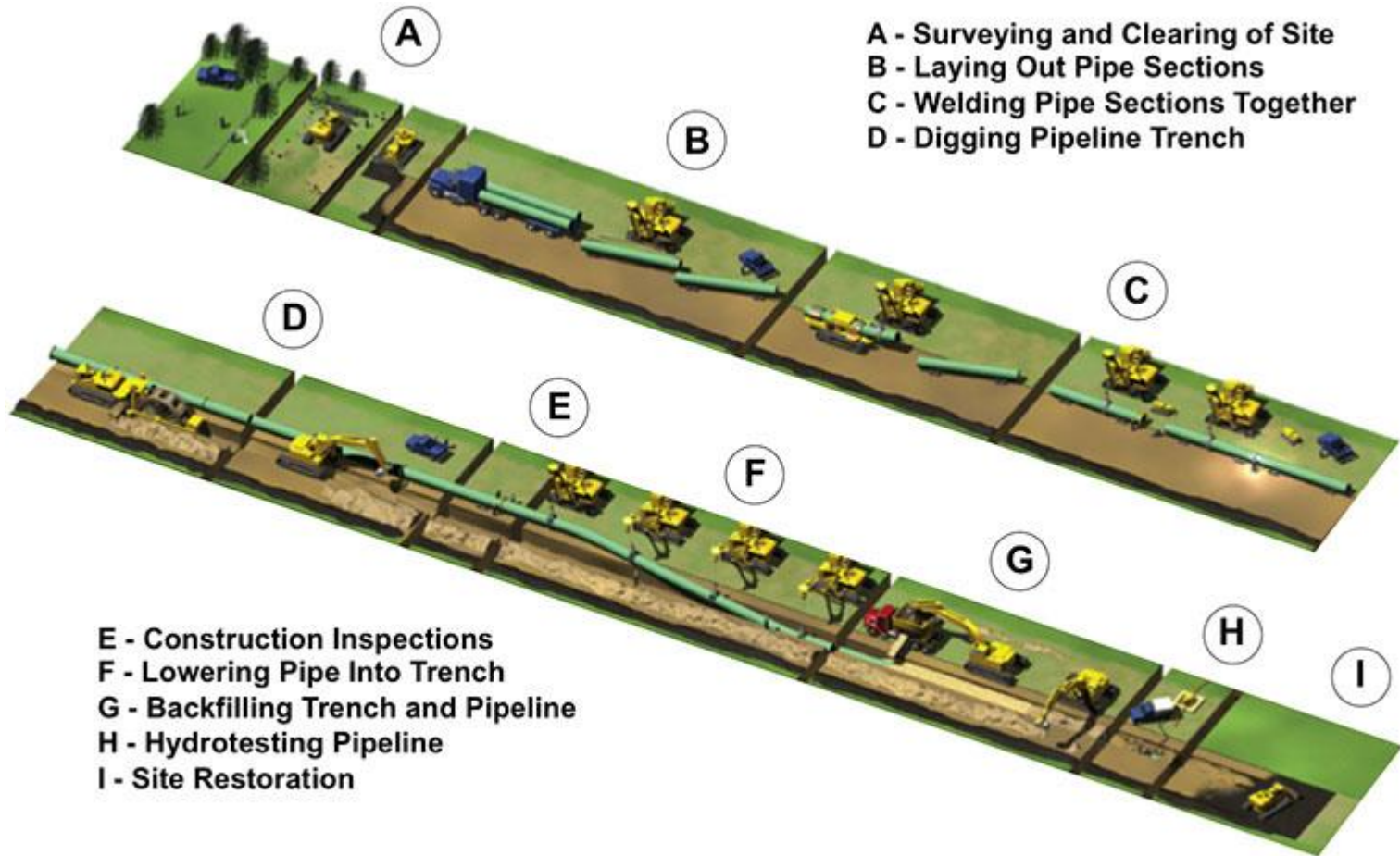
- Pipe Manufacturing Process and Grade:
  - High Frequency Electric Welded (**HFW**)
  - Electric Resistance Welding (**ERW**)
  - Double Submerged Arc Welding (**DSAW**) / Longitudinally submerged arc-welded pipes (**LSAW**)
  - **NO HSAW**
  - Preferred Grade: X65 or X70



## CO<sub>2</sub> Pipelines-Coating

- Fusion Bonded Epoxy (FBE):
  - Standard Pipe
- FBE+ Abrasive Resistant Overlay (ARO)
  - Crossings (heavy Wall)
  - HDD/RRC/Highways/Roads/Water
- Powder Manufactures:
  - Valspar
  - Dupont
  - 3M

# Pipeline Construction Sequence



A - Surveying and Clearing of Site  
B - Laying Out Pipe Sections  
C - Welding Pipe Sections Together  
D - Digging Pipeline Trench

E - Construction Inspections  
F - Lowering Pipe Into Trench  
G - Backfilling Trench and Pipeline  
H - Hydrotesting Pipeline  
I - Site Restoration