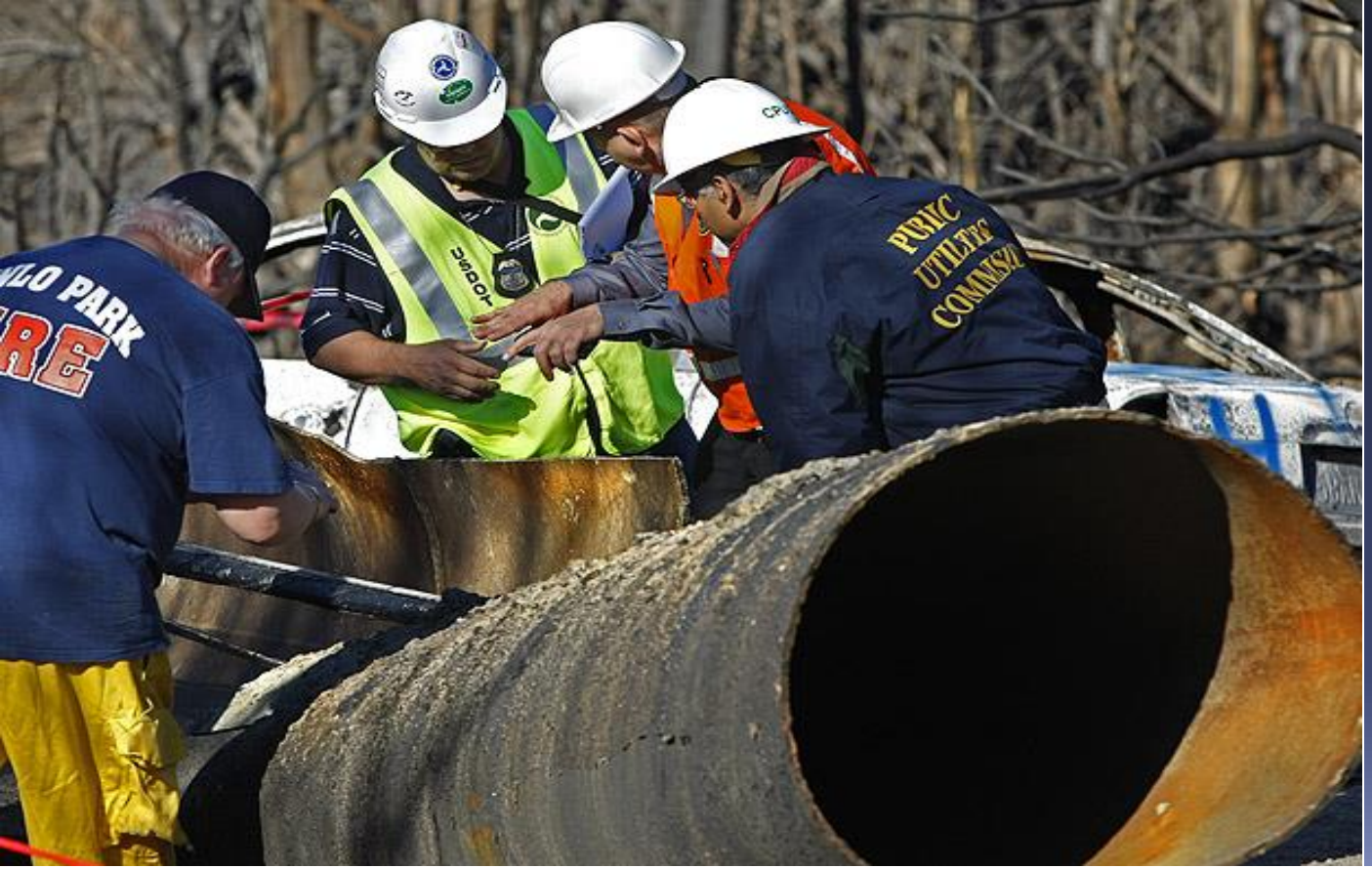


Pipeline and Hazardous Materials Safety Administration

(PHMSA)

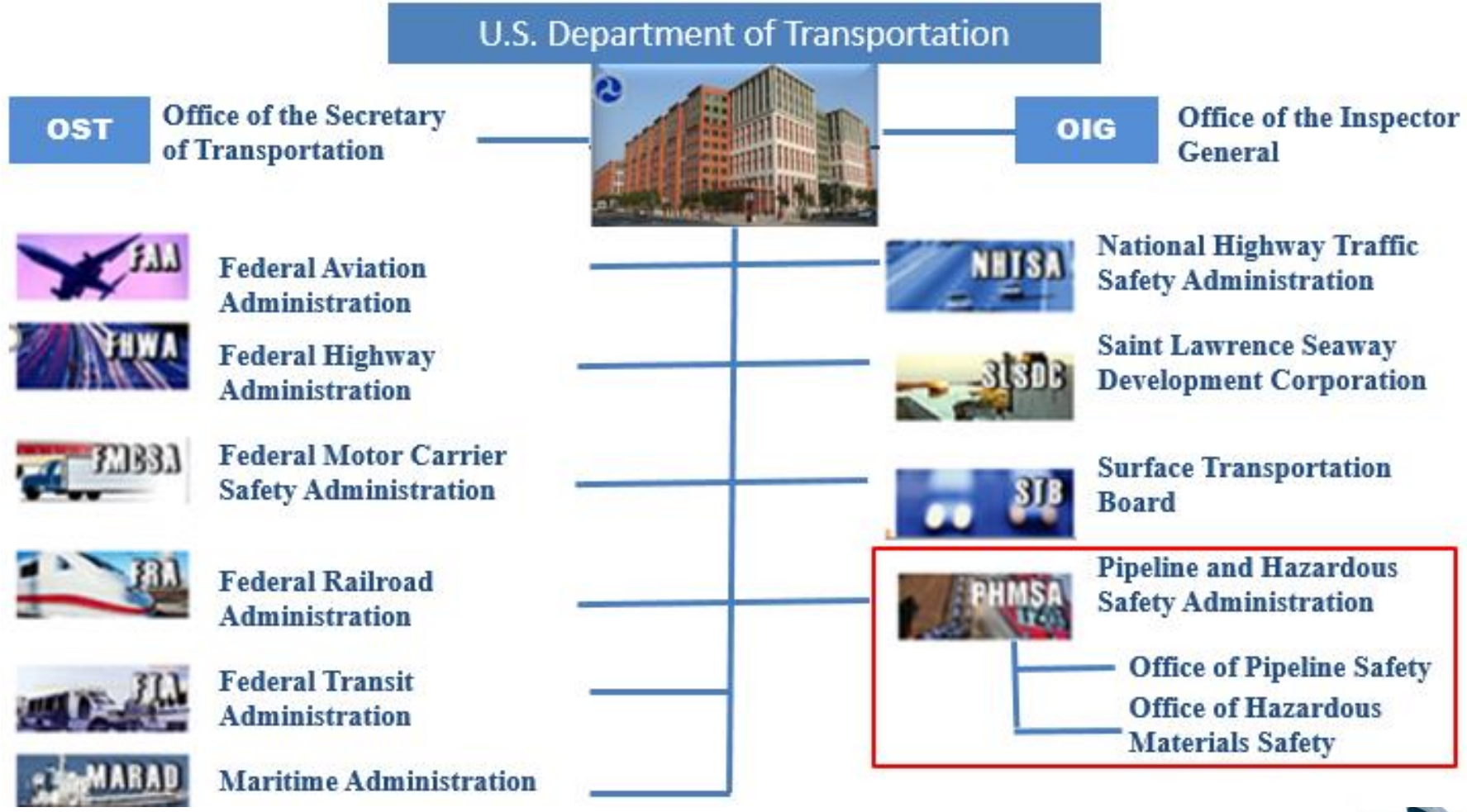
Office of Pipeline Safety

Hydrogen and Carbon Dioxide Pipelines and Carbon Capture Utilization and Storage (CCUS)

July 9, 2024

Harrisburg, Pennsylvania

Who is PHMSA?


U.S. Department of Transportation
OST
Office of the Secretary of Transportation
OIG
Office of the Inspector General
FAA
Federal Aviation Administration
FHWA
Federal Highway Administration
FMCSA
Federal Motor Carrier Safety Administration
FRA
Federal Railroad Administration
FTA
Federal Transit Administration
MARAD
Maritime Administration
NHTSA
National Highway Traffic Safety Administration
SLSDC
Saint Lawrence Seaway Development Corporation
STB
Surface Transportation Board
PHMSA
Pipeline and Hazardous Safety Administration
Office of Pipeline Safety
Office of Hazardous Materials Safety

Our Mission

To protect people and the environment by **advancing the safe transportation of energy and other hazardous materials** that are essential to our daily lives.

PHMSA By the Numbers

3.3 Million	1.2 Million	16,700	1.6 Billion	64%
Miles of Regulated Pipelines	Daily Shipments of Hazardous Materials	Underground Natural Gas Storage Wells	Tons of Hazardous Materials Shipped Annually by All Modes	Of U.S. Energy Commodities Transported by Pipeline

Program Offices

PHMSA performs its mission through two primary safety programs:

Office of Pipeline Safety (OPS)

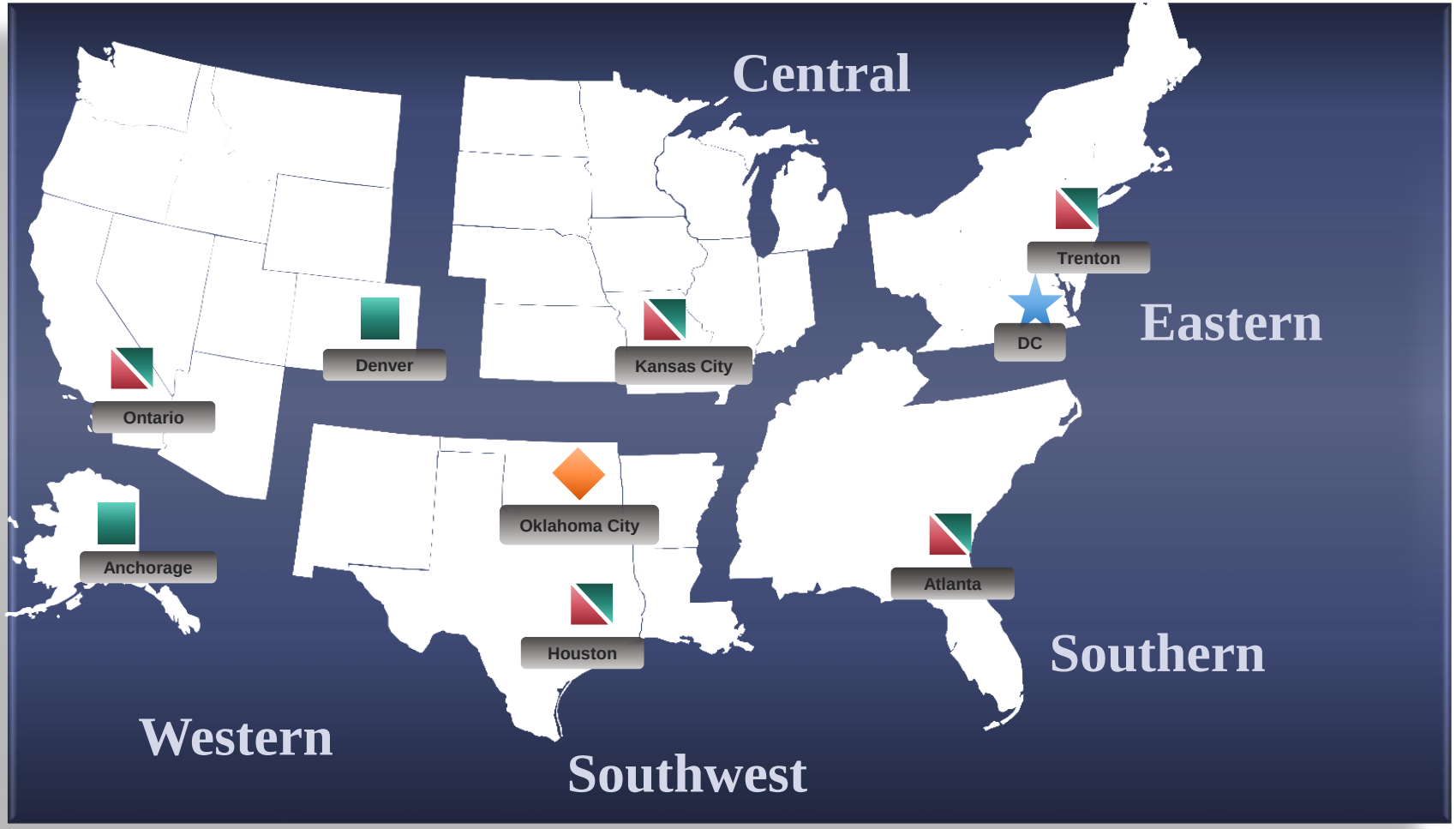
Pipelines transport and supply more than two thirds of the fuel used to heat, cool, and operate American homes, cars, and businesses. It maintains oversight over 3.3 million miles of regulated pipelines.

Office of Hazardous Materials Safety (OHMS)

OHMS oversees the safe and secure shipment of close to one million daily movements of hazardous materials carried by highway, rail, vessel, and air.

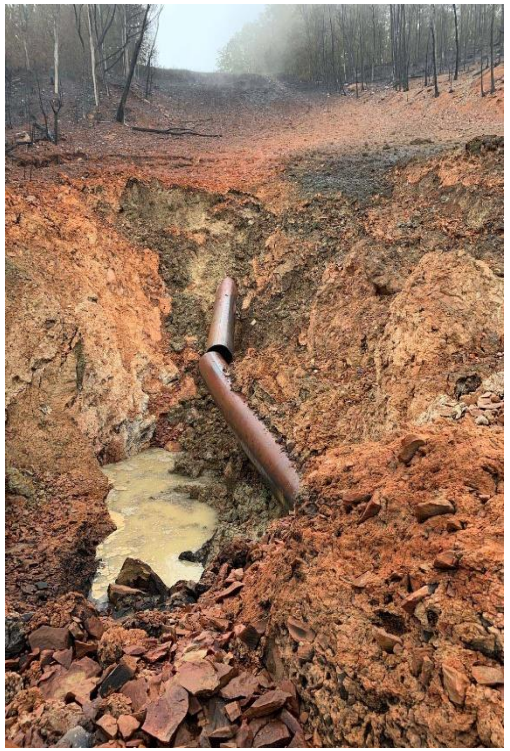
These materials are essential to the American economy for use in farming, medical applications, manufacturing, mining, and other industrial processes.

Where We are Located



- Pipeline Office
- HAZMAT Office
- Pipeline & HAZMAT Office
- Headquarters
- Training Center

We Work to Prevent Accidents Like These



Our Focus

Inspection & Enforcement

Inspect pipeline facilities to determine compliance with our Federal Pipeline Safety Regulations and assess penalties to pipeline operators not in compliance

Accident Investigation

Investigate accidents and incidents involving pipeline failures or releases and share lessons learned to prevent repeat failures

Risk Analysis

Analyze safety performance, improve data quality and analytical capabilities to identify, assess and manage safety risks

Our Tools

Grants

Award safety grants to support pipeline safety inspection, enforcement and outreach programs by states, territories, and non-profits

Research & Development

Support research to improve pipeline safety

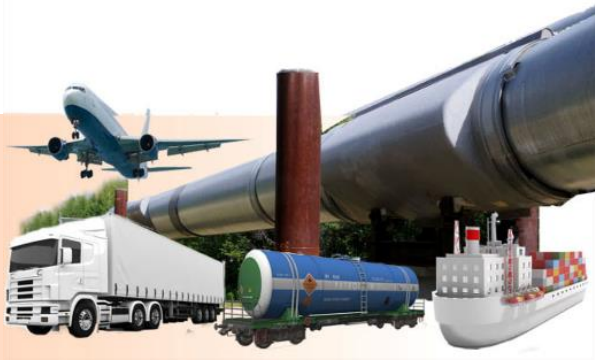
Regulations & Standards

Develop effective regulations and standards to advance pipeline safety

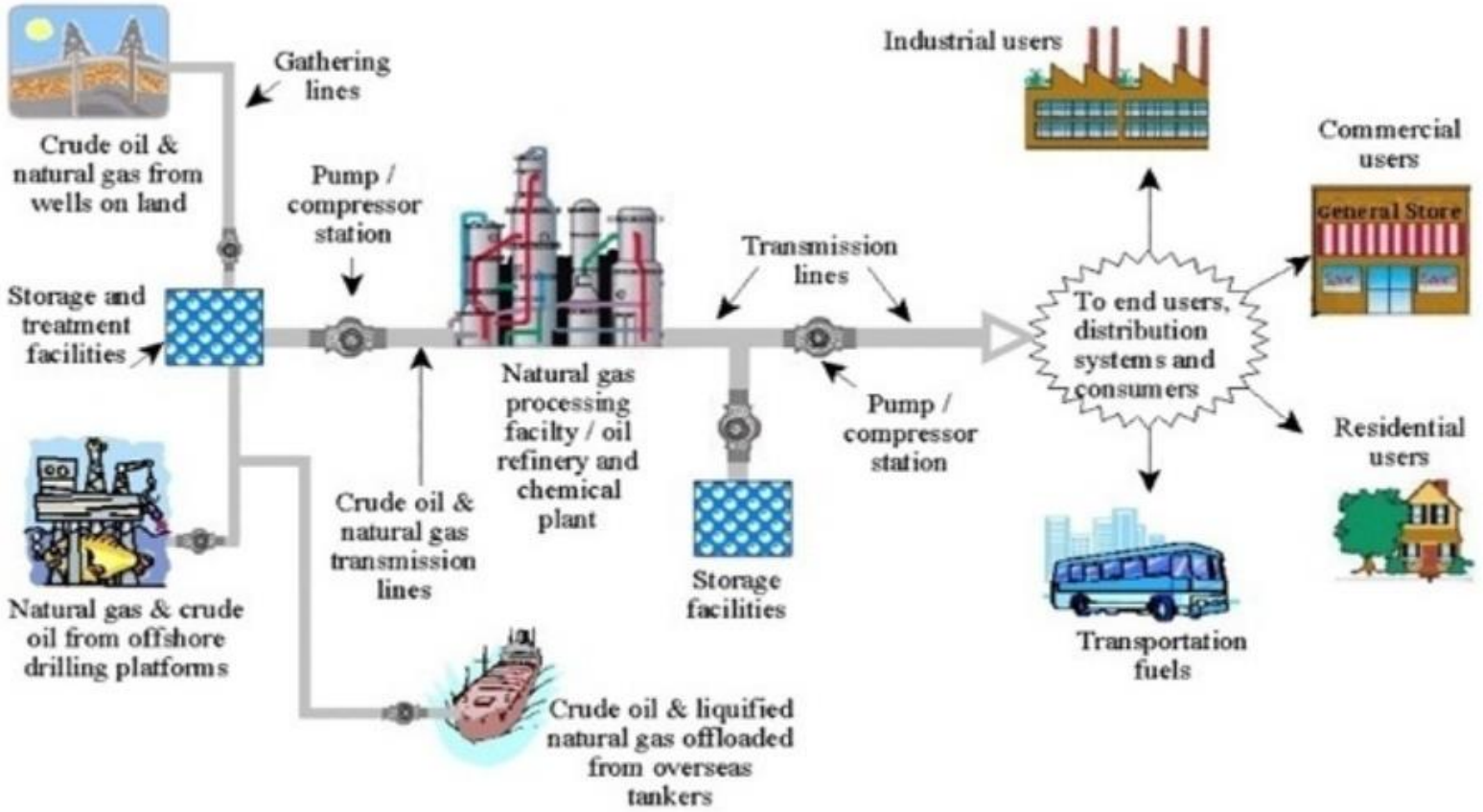
Outreach

Enhance safety and education through stakeholder outreach and engagement

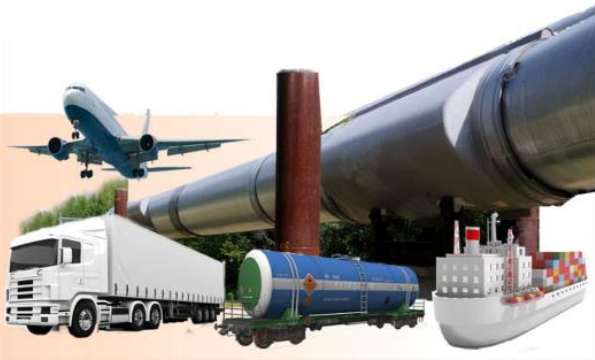
Pipelines



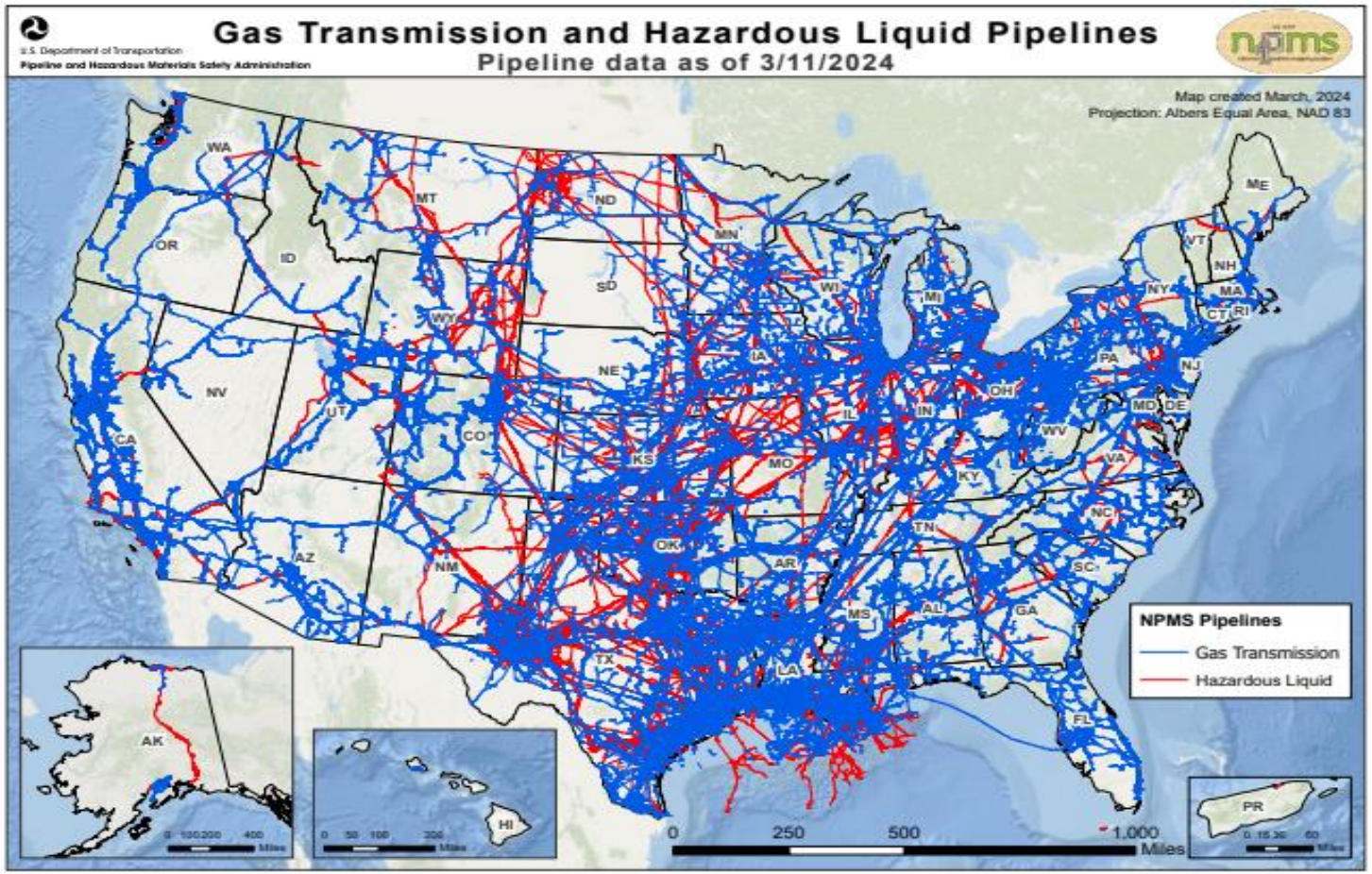
Transmission Pipelines



https://primis.phmsa.dot.gov/comm/FactSheets/FSTransmissionPipelines.htm



Gas Transmission and Hazardous Liquid Pipelines in the United States



https://www.npms.phmsa.dot.gov/

PHMSA Regulated Pipeline Facilities in PA

Data as-of 7-2-2024

Pipeline Facilities by Sy

System Type	
Hazardous Liquid Excludes Gravity and Reporting-Regulated Gathering	
Gas Transmission	56
Gas Gathering	60
Gas Distribution (main miles and	37
Total	

Pipeline Miles by Commodity – Hazardous Liquid

Commodity	Interstate Miles	Intrastate Miles	Total Miles
Crude Oil	42.6	0	43
HVL Flamm Toxic	1,557.6	37.9	1,596
Refined PP	2,543.5	42.9	2,586

Pipeline Miles by Commodity - Gas Transmission

Commodity	Interstate Miles	Intrastate Miles	Total Miles
Hydrogen Gas	0	1.8	1.8
Landfill Gas	0	23	23
Natural Gas	9,286.3	1,088.1	10,374.4
Other Gas	0	34.6	34.6

Hazardous Liquid Breakout Tanks

162 Tanks

Liquefied Natural Gas

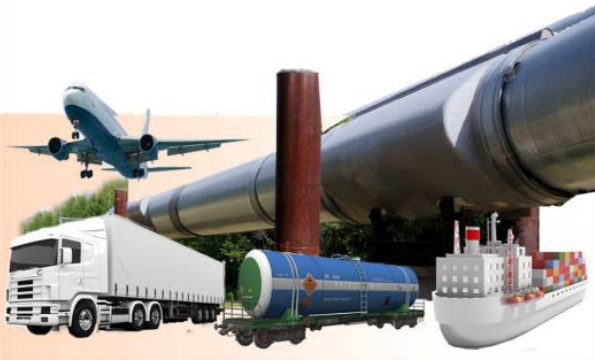
10 Plants, 15 Tanks, 3 Operators

Underground Natural Gas Storage

49 Facilities, 49 Reservoirs, 1,665 Wells, 10 Operators

https://www.phmsa.dot.gov/data-and-statistics/pipeline/pipeline-mileage-and-facilities

Hydrogen Pipelines (H_2)



Background

- PHMSA has regulated the transportation of Hydrogen gas by pipeline since 1970

- Limited regulatory differences between Hydrogen and Natural Gas pipeline transportation

Hydrogen fueled car - Photo Courtesy of DOE

Hydrogen Storage - Photo Courtesy of DOE

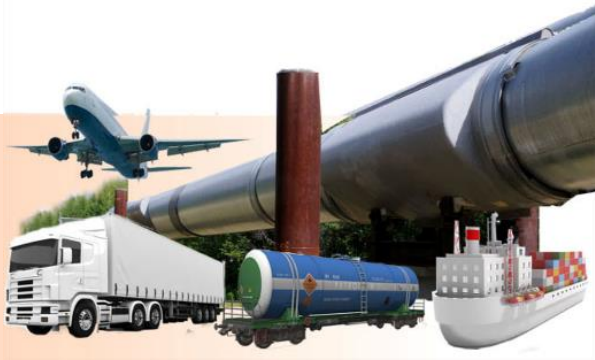
https://primis.phmsa.dot.gov/comm/hydrogen.htm

49 CFR Part 192

49 CFR Part 192 Regulations Unique to Hydrogen Gas Pipelines

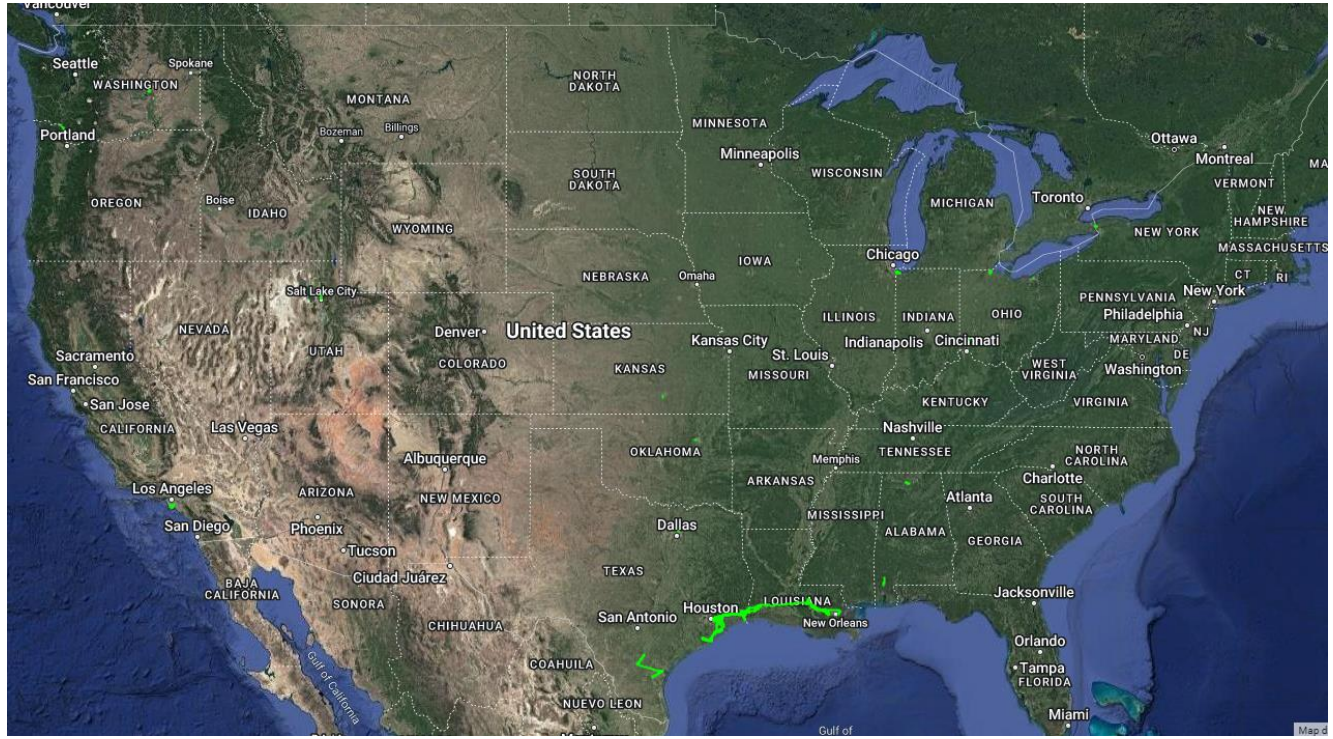
- 49 CFR § 192.625(b), when hydrogen gas is intended to be used as feedstock for a manufacturing process, it does not have the requirement to be odorized in Class 3 and 4 locations

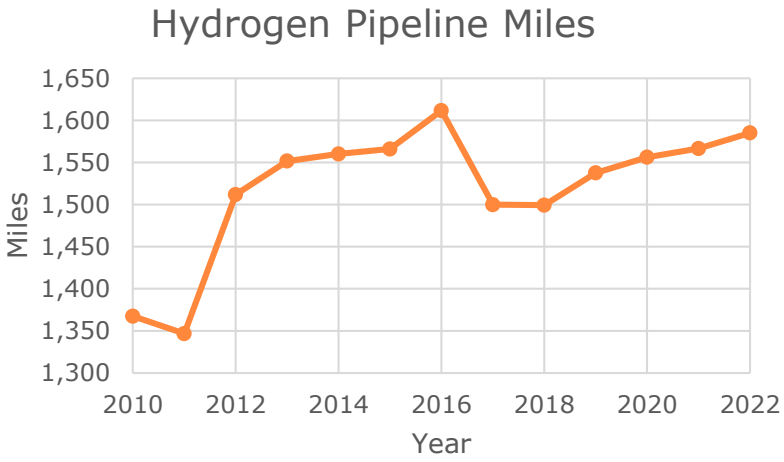
- 49 CFR § 192.53 General: “Materials for pipe and components must be:” (…) “(b) Chemically compatible with any gas that they transport and with any other material in the pipeline with which they are in contact”



Hydrogen Gas Transmission Pipelines in the United States

1,585 Miles





All Pipelines: PHMSA Regulates 3.3 M Miles Total

Hydrogen Gas Transmission Incidents

- Since 2010, there have been five reported hydrogen incidents
- The average release of these five incidents was 1914 MCF (one thousand cubic feet) and the maximum was 6937 MCF
- No injuries or fatalities have been reported

https://www.phmsa.dot.gov/data-and-statistics/pipeline/pipeline-incident-20-year-trends

Ongoing Hydrogen Pipeline Research and Development - 1 of 3

Currently 11 active projects related to hydrogen pipelines with a total of $10.6 million in PHMSA funding and an additional $2.5 million in cost sharing.

Project	Goals
"Knowledge-guided Automation for Integrity Management of Aging Pipelines (KAI-MAP) for Hydrogen Transport" ***Category: Threat Prevention***	Develop an AI-enabled automation framework for pipeline integrity management for emerging fuels, such as hydrogen. Additionally, the researcher will develop decision support tools using AI interfacing with goal-oriented optimization and a context-driven platform to recommend potential pipeline risk mitigation measures. *Researcher: Arizona State University* *PHMSA: $844,726*
"Development of Compatibility Assessment Model for Existing Pipelines for Handling Hydrogen-Containing Natural Gas" ***Category: Threat Prevention***	Use data analytics-based modeling techniques to create a compatibility assessment model which determines the capability of existing pipelines with blended and pure hydrogen gas. Develop a publicly available software tool that operators can use to determine suitability of existing pipelines for pure hydrogen or blended gas and identify needed modifications. *Researcher: University of Oklahoma* *PHMSA: $1,000,000*
"Accelerating Transition towards Sustainable, Precise, Reliable Hydrogen Infrastructure (Super-H2): Holistic Risk Assessment, Mitigation Measures, and Decision Support Platforms" ***Category: Threat Prevention***	Develop and implement a holistic framework for an AI-powered, platform-forward software tool that will accelerate the transition of existing gas pipelines for hydrogen transport. *Researcher: North Dakota State University* *PHMSA: $1,000,000*
"Investigate Damage Mechanisms for Hydrogen and Hydrogen/Natural Gas Blends to Determine Inspection Intervals for In-Line Inspection Tools" ***Category: Anomaly Detection & Characterization***	Analyze failure mechanisms related to hydrogen and hydrogen/natural gas blends, develop knowledge regarding critical flaw sizes and availability and accuracy of ILI tools, and recommend changes to practices for determining reinspection intervals. *Researcher: Kiefner and Associates, Inc.* *PHMSA: $1,200,000*

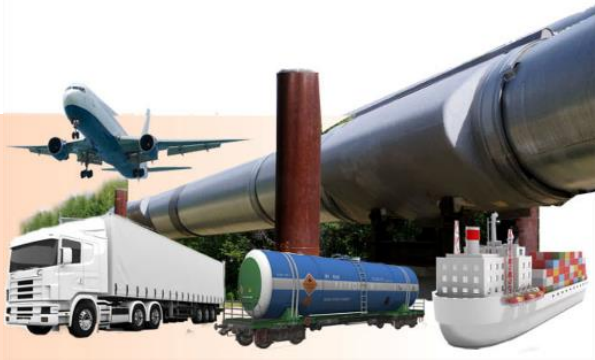
https://primis.phmsa.dot.gov/matrix/

Ongoing Hydrogen Pipeline Research and Development - 2 of 3

Project	Goals
"Determining Steel Weld Qualification and Performance for Hydrogen Pipelines" ***Category: Materials***	Review current codes and standards for gaps in qualification requirements for welds in pipelines intended for hydrogen transportation and provide the following: weld qualification requirements for new steel pipeline assets; performance evaluations for varying modern steel grades; and assessment parameters for evaluating the integrity of existing and vintage (pre-Code) assets. *Researcher: National Institute of Standards and Technology PHMSA: $2,060,000*
"Investigating the Integrity Impacts of Hydrogen Gas on Composite/Multi-Layered Pipe" ***Category: Materials***	Investigate the impact to the integrity of composite pipe when used to transport pressurized hydrogen gas. Identify and address safety hazards to the pipeline facilities, people, and the surrounding environment. Identify required design, material and construction specifications, maintenance procedures, and a roadmap for using alternative-steel and non-steel composite systems for composite pipelines. *Researcher: Edison Welding Institute, Inc. PHMSA: $450,078*
"Advancing Hydrogen Leak Detection and Quantification Technologies Compatible with Hydrogen Blends" ***Category: Leak Detection***	Investigate the impact of hydrogen on leakage dynamics and existing leak detection equipment. This will inform new approaches for hydrogen sensing and integration into next-generation leak detection equipment. *Researcher: Gas Technology Institute PHMSA: $749,446*
"Determining the Required Modifications to Safely Repurpose Existing Pipelines to Transport Pure Hydrogen and Hydrogen-Blends" ***Category: Climate Change***	Determine practical methods for repurposing existing pipeline networks for the safe transport of hydrogen or hydrogen blends; and identify which existing gas transmission pipeline components may need modifications to safely introduce hydrogen gas or natural gas/hydrogen blends. *Researcher: Engineering Mechanics Corporation of Columbus PHMSA: $800,000*

Ongoing Hydrogen Pipeline Research and Development - 3 of 3

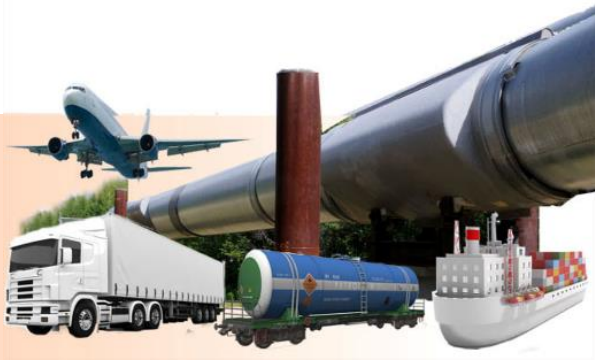
Project	Goals
"Review of Integrity Threat Characterization Resulting from Hydrogen Gas Pipeline Service" ***Category: Climate Change***	Identify differences between existing integrity threats and possible new threats resulting from the presence of hydrogen. Define a list of possible changes to the ASME threat assessment process to address hydrogen, or hydrogen blended service-based threats in new or existing pipelines. *Researcher: Engineering Mechanics Corporation of Columbus PHMSA: $240,000*
"Expanding Hydrogen Storage to Porous Rock Formations: A Framework for Estimating Feasibility & Operational Considerations" ***Category: Underground Natural Gas Storage***	Develop a framework to expand underground hydrogen storage beyond salt caverns to other formation types. Provide a set of operational considerations for selecting suitable porous rock formations. Establish guidelines for monitoring potential hydrogen movement or loss from geochemical reactions or multiphase hydrogen flow with formation fluids. *Researcher: Gas Technology Institute PHMSA: $298,000*
"Establishing the Technical Basis for Enabling Safe and Reliable Underground Hydrogen Storage Operations" ***Category: Underground Natural Gas Storage***	Identify and understand existing PHMSA regulatory functions and needs as they relate to characterizing, permitting, and assessing underground natural gas storage (UGS) operations within the subsurface in order to define appropriate metrics relevant to UHS. Quantify the suitability of existing UGS facilities (which includes the well and subsurface geologic system) for storing pure and blended hydrogen. Characterize operational expectations with emphasis on quantifying risk for H2 resource loss processes, UGS asset degradation, and estimating transient behavior based on geologic and operational conditions. *Researcher: Fossil Energy and Carbon Management PHMSA: $2,000,000*



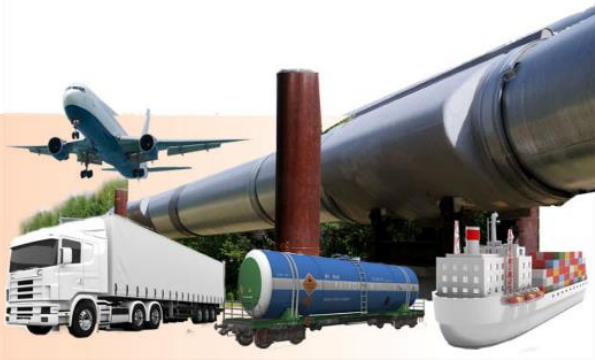
Hydrogen – Information Collection

Proposed Information Collection

- Published in the Federal Register on March 25, 2024
- Proposal to revise PHMSA forms to collect data on the blending of hydrogen gas with natural gas within gas pipelines, among other changes related to the Valve Rule
- Comment period extended until June 24, 2024
- Link to docket PHMSA-2022-0085 https://www.regulations.gov/docket/PHMSA-2022-0085/



Carbon Dioxide Pipelines (CO_2)

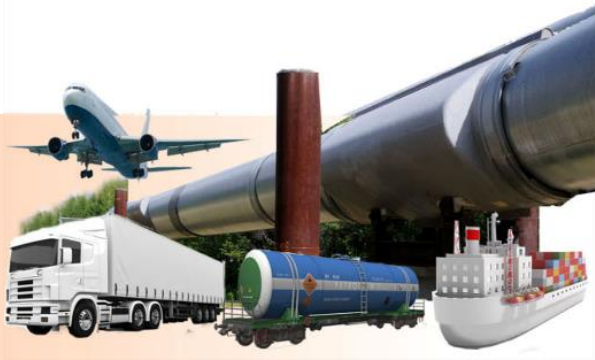


Background

- August 1986 a catastrophic release of CO_2 in Lake Nyos, Cameroon, Africa killed 1,700 people
- Lake Nyos did not involve a pipeline but showed the potential consequence
- Pipeline Safety Reauthorization of 1988, Section 211, required DOT to develop regulations for the transportation of CO_2 by pipeline
- DOT added CO_2 into Part 195 effective July 1992
- Pipeline Safety Act of 2011, Section 15 mandated DOT "prescribe minimum safety standards for the transportation of carbon dioxide by pipelines in a gaseous state."
    - PHMSA found that there were few gaseous CO_2 pipelines and that no foreseeable needs justified addition to Part 192 at that time

Dual Track Oversight

CO_2 Phase	Safety Authority	Regulatory Authority
Supercritical	✓	✓
Gaseous	✓	Working on it!

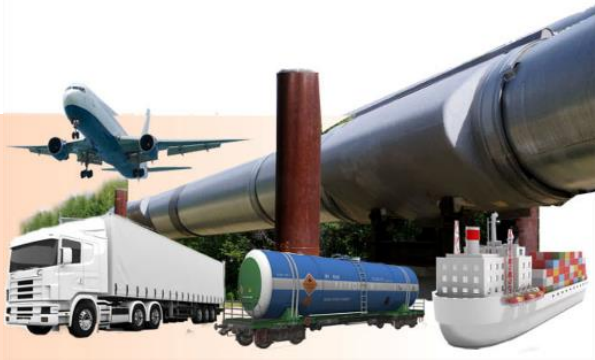


49 CFR Part 195

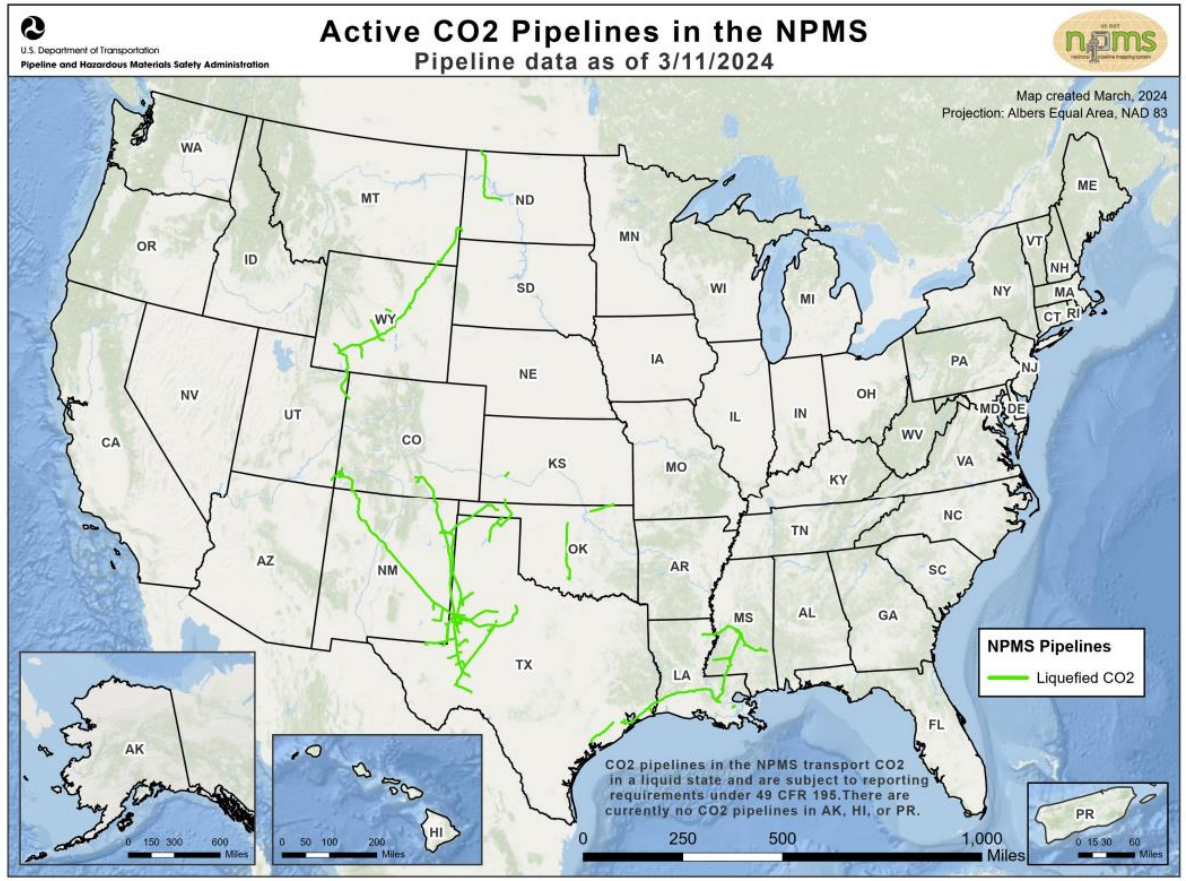
- PHMSA regulates the transport of supercritical CO_2 under 49 CFR Part 195

49 CFR Part 195 Regulations Unique to CO_2 Pipelines

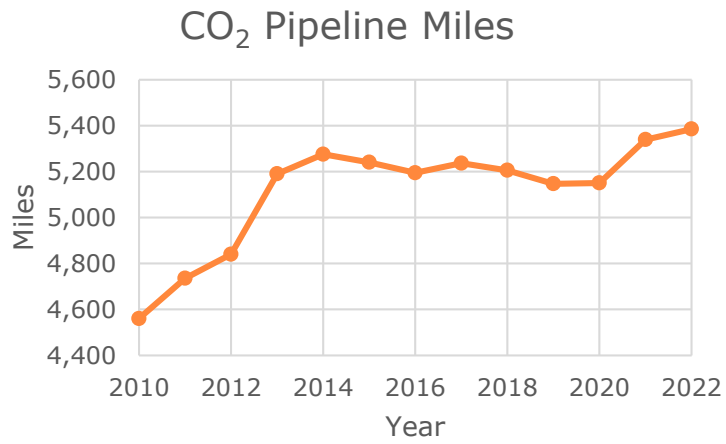
- 49 CFR § 195.1(b)(10) Location applicability exceptions
- 49 CFR § 195.102 Design for low temperatures
- 49 CFR § 195.111 Design to mitigate fracture propagation
- 49 CFR § 195.302(b)(2) Pressure testing exceptions
- 49 CFR § 195.306(c) Conditions for use of inert gas or CO_2 as test medium



CO_2 Pipelines in the United States



https://www.npms.phmsa.dot.gov/Documents/NPMS_CO2_Pipelines_Map.pdf



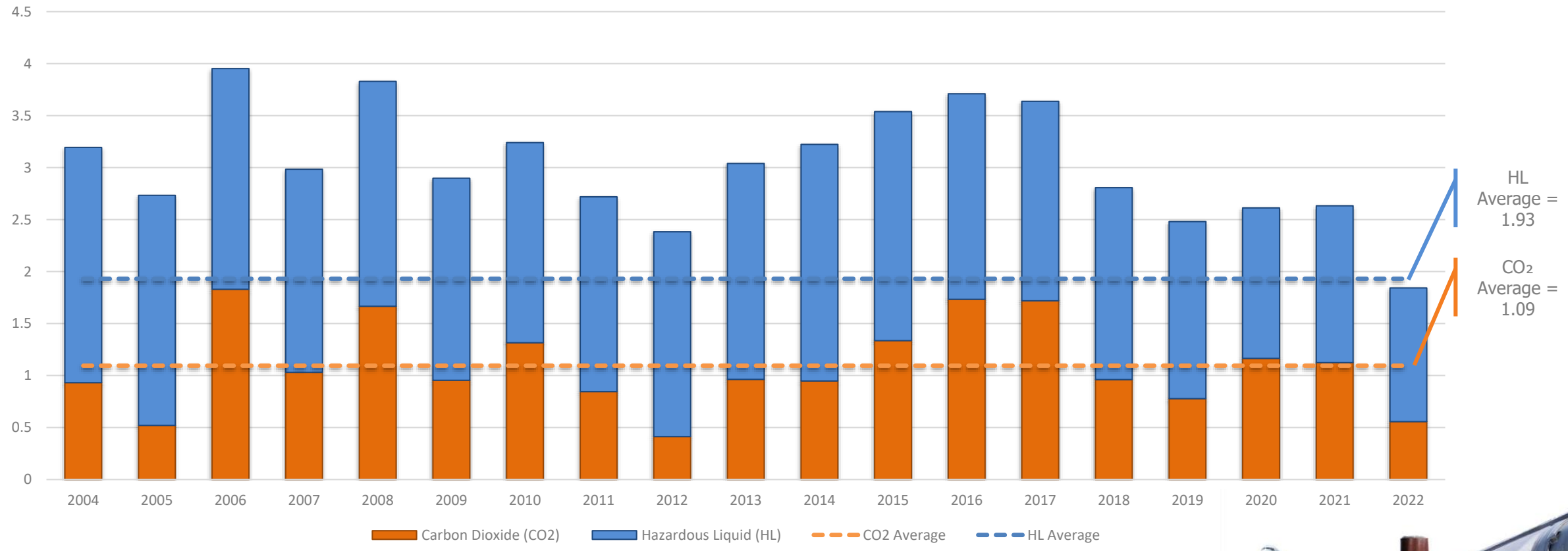
5,385 Miles

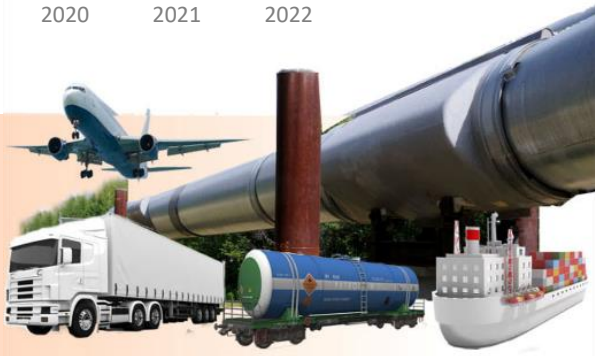
All Pipelines: PHMSA Regulates
3.3 M Miles Total

CO_2 Transport – a Mature Operation

PHMSA's pipeline incident 20-year trends

Incident Rate Per 1,000 Miles - 2004 to 2022





Satartia, Mississippi

PHMSA Failure Investigation Report - Denbury Gulf Coast Pipelines, LLC

Figure 2: Vehicle is Parked on HWY 433 - The White is Ice Generated by the Release of CO_2 - The Blue Arrow Points North (Aerial Drone Photograph Courtesy of the Mississippi Emergency Management Agency)

https://www.phmsa.dot.gov/news/phmsa-failure-investigation-report-denbury-gulf-coast-pipelines-llc

2022 PHMSA Announcement

United States Department of Transportation

U.S. Department of Transportation
Pipeline and Hazardous Materials Safety Administration

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Related Links

- Federal Register - Pipeline Safety: Potential for Damage to Pipeline

PHMSA Announces New Safety Measures to Protect Americans From Carbon Dioxide Pipeline Failures After Satartia, MS Leak

Thursday, May 26, 2022

PHMSA 05-22
Contact: PHMSAPublicAffairs@dot.gov

WASHINGTON - The U.S. Department of Transportation's Pipeline and Hazardous Materials Safety Administration (PHMSA) today announced it is taking steps to implement new measures to strengthen its safety oversight of carbon dioxide (CO_2) pipelines around the country and protect communities from dangerous pipeline failures. The new measures, as well as an enforcement action taken today are a result of PHMSA's investigation into a CO_2 pipeline failure in Satartia, Mississippi in 2020 that resulted in local evacuations and caused almost 50 people to seek medical attention.

https://www.phmsa.dot.gov/news/phmsa-announces-new-safety-measures-protect-americans-carbon-dioxide-pipeline-failures

Carbon Dioxide – Rulemaking

RIN 2137-AF60

- Notice of Proposed Rulemaking (NPRM) Stage

- NPRM
  - Enhance the safe transportation of carbon dioxide by pipeline
  - Include requirement related to emergency preparedness and response for carbon dioxide

PIPES Act Web Chart available at:
https://www.phmsa.dot.gov/legislative-mandates/pipes-act-web-chart

CO_2 Safety Public Meeting 2023 – 1 of 2

Event Purpose:

- Help inform rulemaking
- Better inform stakeholders
- Share Data/Technology/Ongoing Efforts
- Address comments/concerns

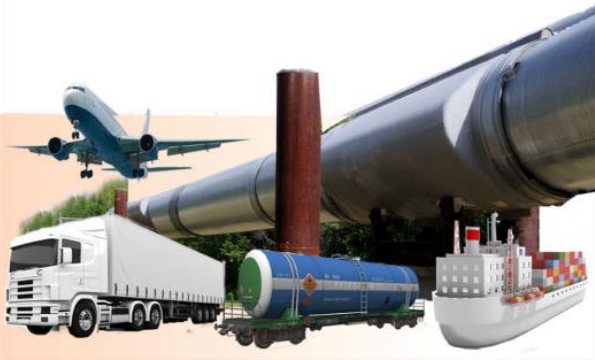
Panel Discussion at the CO2 Safety Public Meeting

Event Summary:

- May 31st - June 1st, 2023
- Over 1000 in-person & virtual attendees
- Meeting and Comments Docket Information: https://primis.phmsa.dot.gov/meetings/MtgHome.mtg?mtg=165

CO_2 Safety Public Meeting 2023 – 2 of 2

- **Major Topics Discussed**
  - Safety expectations for pipeline operators
  - General state of CO_2 pipeline infrastructure – current mileage and forecasts
  - Federal and state jurisdictions and authorities
  - Public awareness, engagement, and emergency notification
  - Emergency equipment, training, and response
  - Dispersion modeling
  - Safety measures to address other constituents besides CO_2 in CO_2 pipelines
  - Leak detection and reporting
  - Geohazards
  - Conversion to service



CO_2 Pipeline Research and Development - 1 of 2

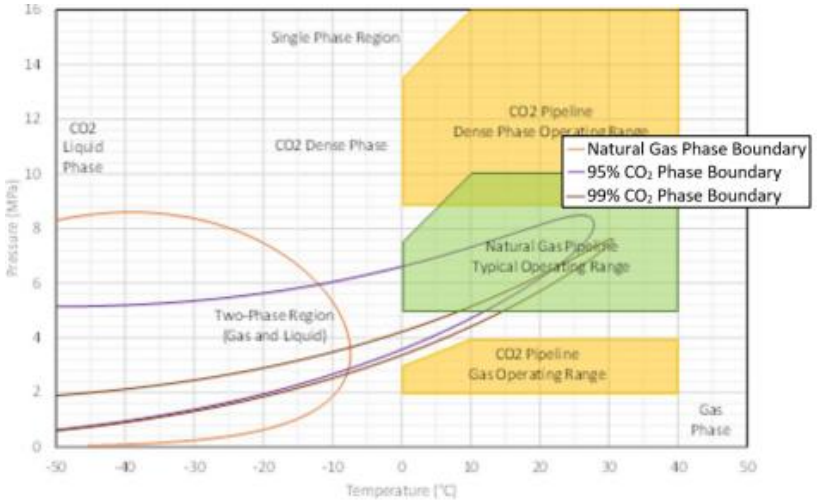
Researcher: BMT Commercial USA
Project Cost: $1,500,000 ($1,200,000 PHMSA + $300,000 cost sharing)
Public Page:
https://primis.phmsa.dot.gov/matrix/PrjHome.rdm?prj=996

Project Objective:

- Identify unique aspects of CO_2 pipeline design, integrity, and operational considerations currently not well supported by existing knowledge.
- Define processes and procedures to fill these safety gaps.
- Identify performance-based safety targets for CO_2 pipelines.

Project End Date: 9/29/2024

Potential Impact on Safety: Will advance the safe transportation of impure CO_2 at both low pressure (gas phase) and high pressure (supercritical and dense phase), by defining the state of knowledge and how it can be applied in CO_2 pipeline design, operation, and maintenance.



Pictures courtesy BMT Commercial USA

CO_2 Pipeline Research and Development - 2 of 2

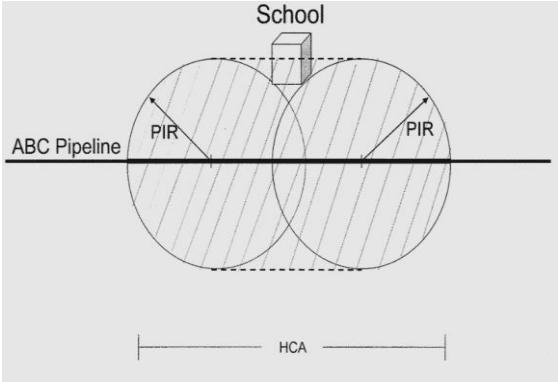
Researcher: Texas A&M Engineering Experiment Station
Project Cost: $359,560 ($279,754 PHMSA + $79,806 cost sharing)
Public Page: https://primis.phmsa.dot.gov/matrix/PrjHome.rdm?prj=987

Project Objective:

- Establish a computational fluid dynamics model to simulate the release and dispersion of supercritical CO_2 from full pipeline ruptures.
- Use the simulation results to construct a database comprising CO_2 dispersion data under different scenarios.
- Use the resulting scenario data in a machine learning analysis for predicting dispersion ranges and health consequences.
- Develop a rapid, universally applicable tool to assess the consequences of accidental CO_2 dispersion from high-pressure pipelines.

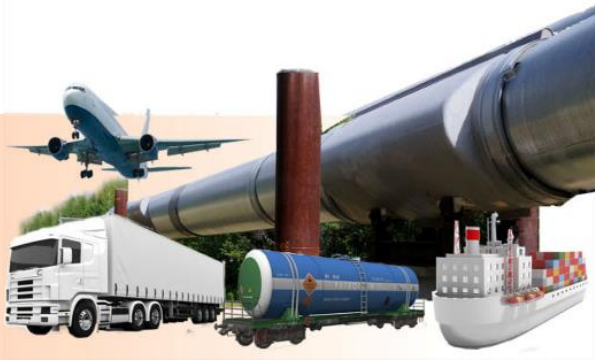
Project End Date: 9/29/2024

Potential Impact on Safety: This tool will allow the user to determine a PIR for CO2 pipelines quickly and easily and can be applied to assess risk during the planning stage and aid emergency responders in formulating response plans and in the event of an emergency.



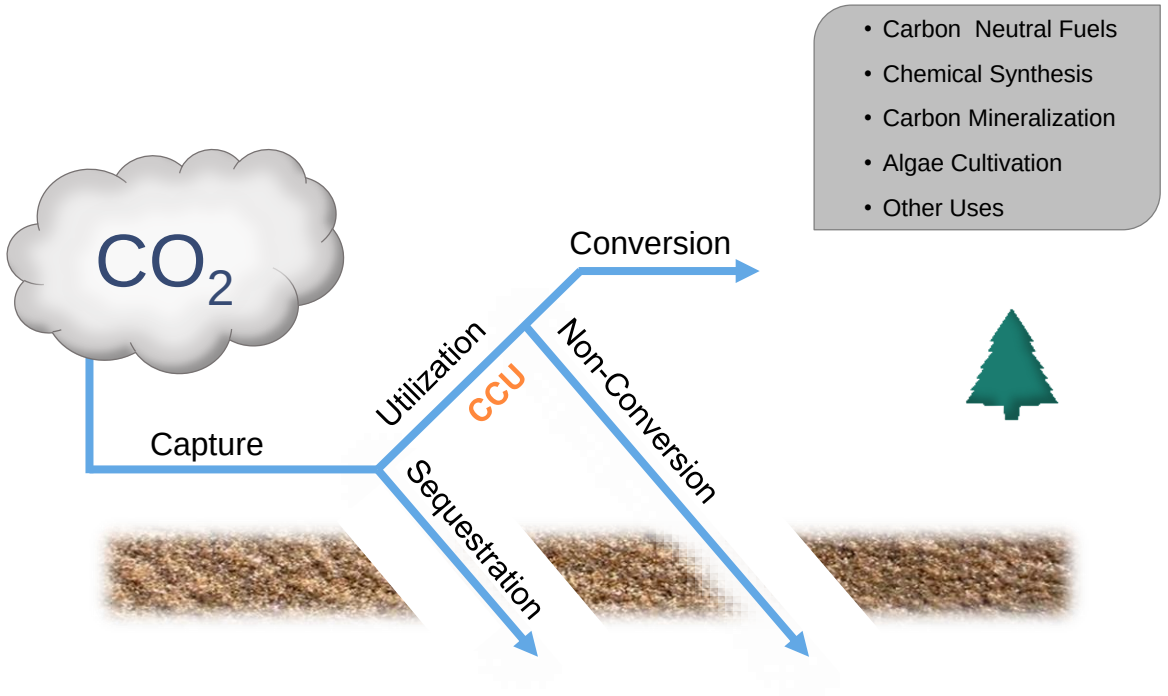
Picture courtesy Texas A&M

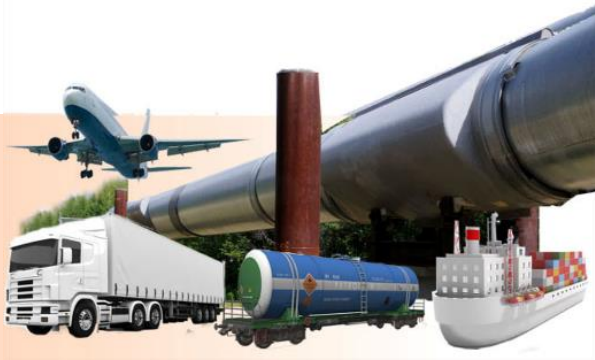
Carbon Capture Utilization and Storage (CCUS)



CCUS

CCUS is an umbrella term for processes that remove CO_2 where it is generated and stores or transports it for use in various industrial applications; both outcomes remove CO_2 from green house gas emissions





Where do Pipelines Fit With CCUS?

- Pipelines connect carbon capture locations to carbon storage and carbon utilization locations
- Primarily involves transportation of supercritical CO_2 through PHMSA regulated pipelines
- Inflation Reduction Act and Bipartisan Infrastructure Law included new incentives for CCUS, prompting new and expanded CO_2 pipeline projects

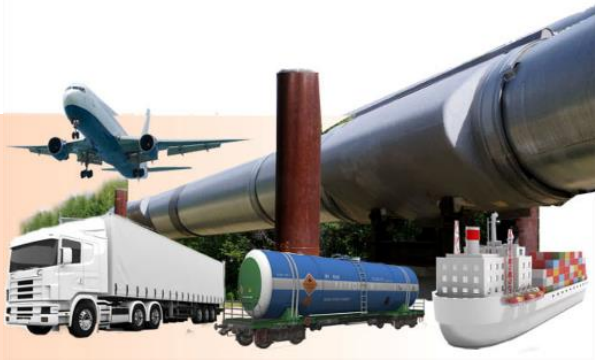
PHMSA Authorities

Yes

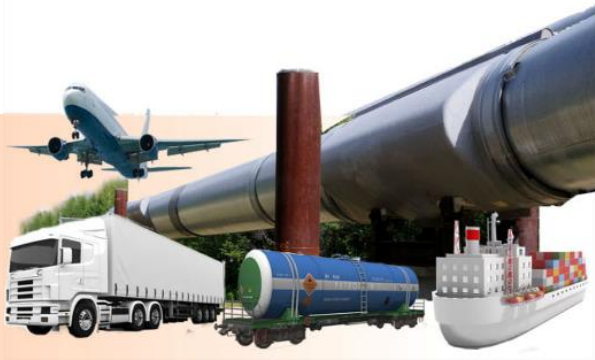
- Regulatory and safety authority for CO_2 onshore and offshore pipeline transportation and intermittent storage associated with transportation

No

- Piping or equipment used in production, extraction, recovery, lifting, stabilization, separation, refining, or manufacturing of CO_2
- Siting; PHMSA cannot prescribe location or routing of a pipeline and cannot prohibit construction of non-pipeline buildings in proximity to a pipeline
- PHMSA's authority does not explicitly reference either carbon capture equipment or permanent sequestration of CO_2



Q&A



Additional Resources

PHMSA Homepage
www.phmsa.dot.gov

Federal Pipeline Safety Regulations (49 CFR 190 - 199)
www.ecfr.gov

Pipeline Terminology and Basics
https://www.phmsa.dot.gov/safety-awareness/pipeline/safety-awareness-overview

Community Toolkit
http://primis.phmsa.dot.gov/comm/

Legislative Mandates
https://www.phmsa.dot.gov/legislative-mandates/mandates-overview

- PIPES Act Monthly Rulemaking Status Update
https://www.phmsa.dot.gov/legislative-mandates/pipes-act-web-chart

Grants
https://www.phmsa.dot.gov/about-phmsa/working-phmsa/grants

PHMSA FY 2023 Pipeline Safety Grants Report
https://www.phmsa.dot.gov/about-phmsa/working-phmsa/grants/pipeline-safety-grants-fy2023

National Pipeline Mapping System
www.npms.phmsa.dot.gov

PHMSA Technical Resources
https://www.phmsa.dot.gov/technical-resources

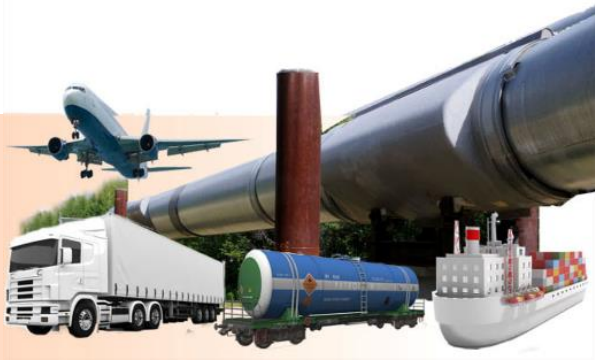
PHMSA FAQs
https://www.phmsa.dot.gov/about-phmsa/phmsa-faqs

Social Media

https://twitter.com/PHMSA_DOT

https://www.youtube.com/user/PHMSADOT

https://www.linkedin.com/company/pipeline-and-hazardous-materials-safety-administration



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