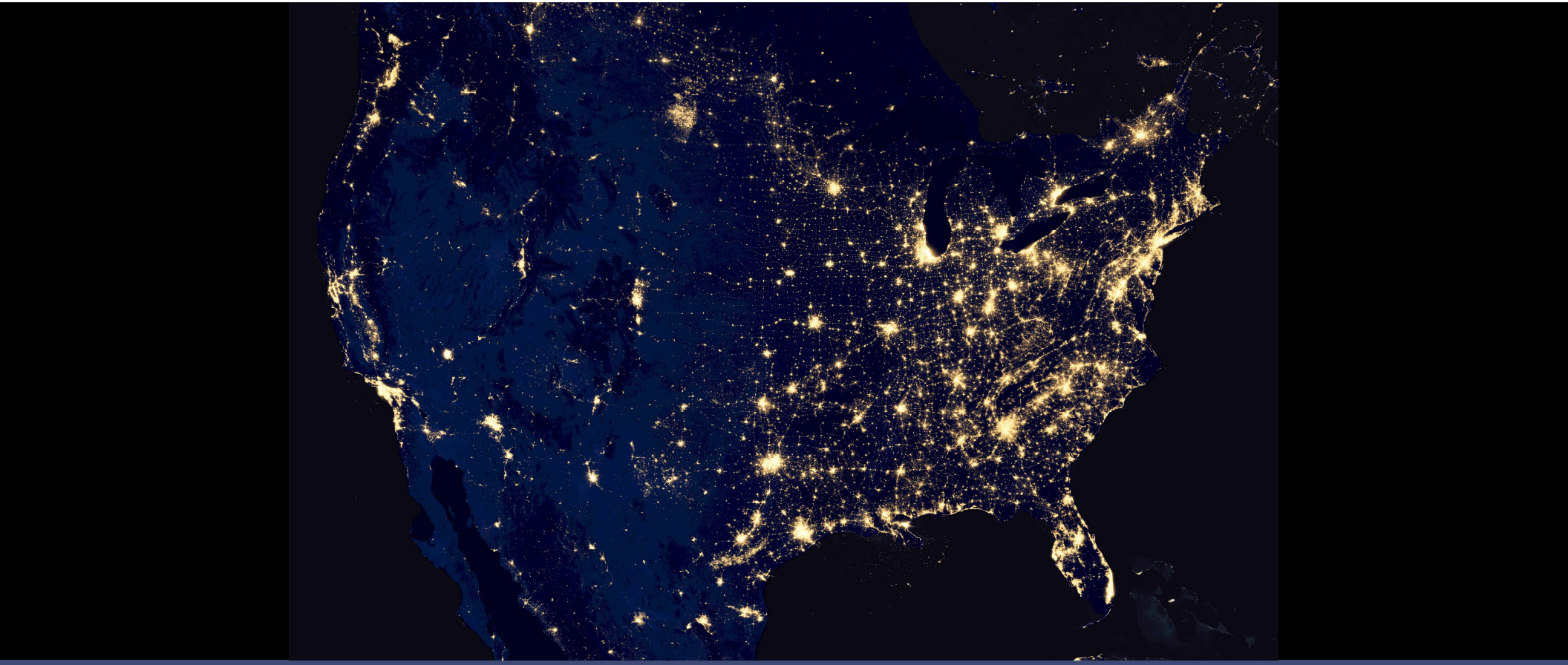


Pipeline and Hazardous Materials Safety Administration

Office of Pipeline Safety

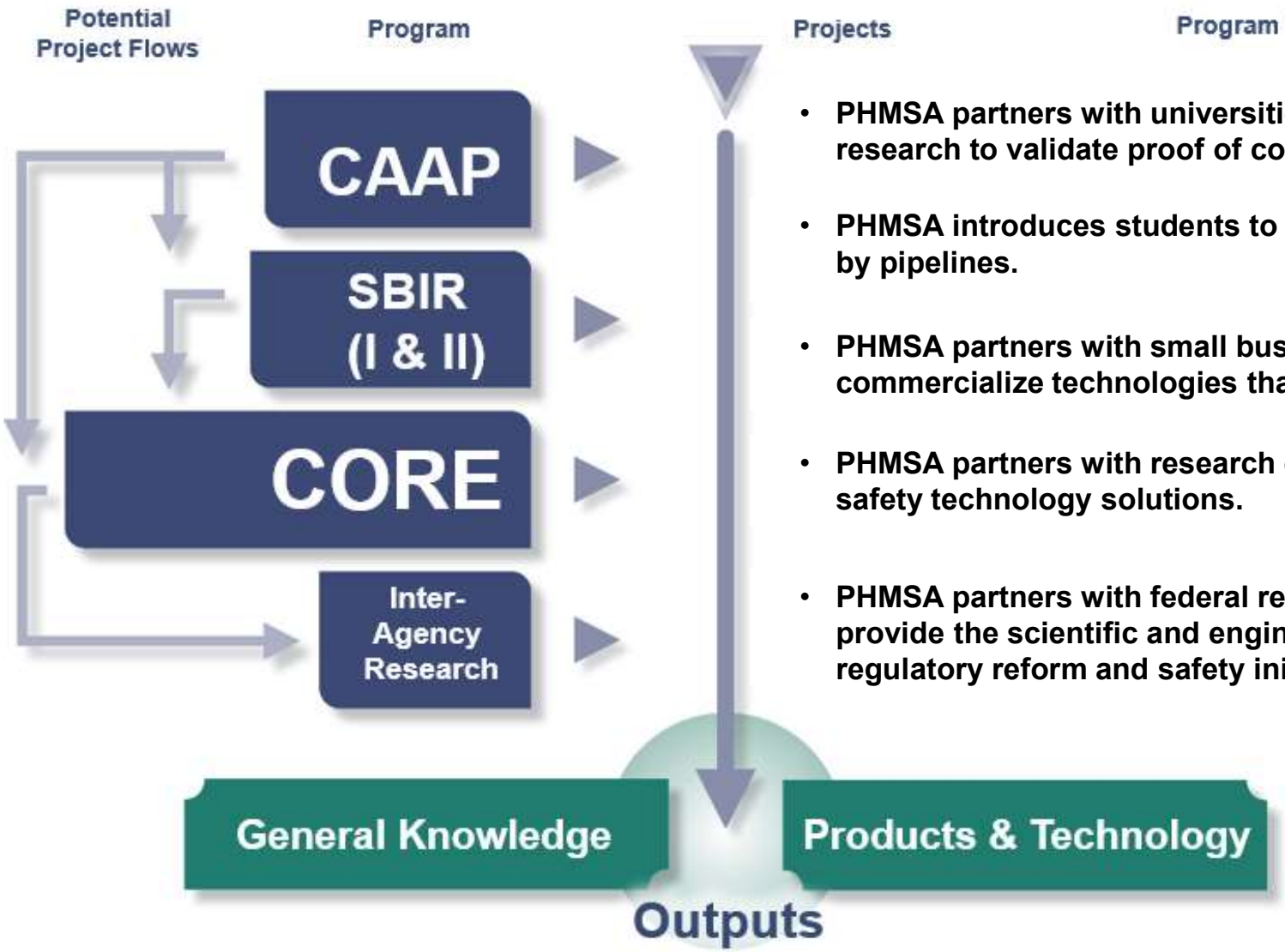
PHMSA's R&D Program and Ongoing Hydrogen Research

Kandilarya Barakat - September 17, 2024

Research and Development Mission

To sponsor research and development projects focused on providing **near-term solutions** for the Nation's pipeline transportation system that will improve **safety**, reduce **environmental impact**, and enhance **reliability**.

R&D Program



Program Scope

- **PHMSA partners with universities on pipeline safety research to validate proof of concept of a thesis or theory.**
- **PHMSA introduces students to transportation of energy by pipelines.**
- **PHMSA partners with small businesses to commercialize technologies that can advance safety.**
- **PHMSA partners with research entities to develop safety technology solutions.**
- **PHMSA partners with federal research entities to provide the scientific and engineering basis for regulatory reform and safety initiatives.**

R&D Focus Areas

Number	Focus Area
1	Liquefied Natural Gas (LNG) Safety
2	Underground Natural Gas Storage (UNGS) Safety
3	Pipeline Anomaly Detection/Characterization
4	Pipeline Leak Detection
5	Pipeline Threat Prevention
6	Repair/Rehabilitation
7	Design & Materials
8	Alternative Fuels Research to Address Climate Change

Total Investment History Since 2002

Name	Amount	Number of Projects
Core Program (Core)	$146.7 M	283 Projects
Competitive Academic Agreement Program (CAAP)*	$24.2 M	73 Projects
Small Business Innovation Research (SBIR) Program	$21.3 M	55 Projects
Inter-Agency Agreement (IAA) Program	$8.8 M	19 Projects
Total	**$201 M**	**430 Projects**

**CAAP launched in 2013*

Data as of 8/27/2024

2023 New Projects Awarded

Program	Total Projects Awarded	Total PHMSA Funding ($)	Total Cost Share ($)
CAAP	6	4,327,086	1,161,203
Core	13	6,782,384	2,633,417
SBIR	5	4,175,568	0
IAA	1	2,000,000	0
Grand Total	23	17,285,038	3,794,620

Ongoing H_2 Pipeline Research

11 active projects totaling $10.6 million in PHMSA funding + $2.5 million in cost sharing

Project	Goals
Determining Steel Weld Qualification and Performance for H2 Pipelines *Category: Materials*	Review current codes and standards for gaps in qualification requirements for welds in pipelines intended for H2 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 H2 Gas on Composite/Multi-Layered Pipe *Category: Materials*	Investigate the impact to the integrity of composite pipe when used to transport pressurized H2 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 H_2 Leak Detection and Quantification Technologies Compatible with H_2 Blends *Category: Leak Detection*	Investigate the impact of H2 on leakage dynamics and existing leak detection equipment. This will inform new approaches for H2 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 H_2 and H_2 Blends *Category: Climate Change*	Determine practical methods for repurposing existing pipeline networks for the safe transport of H2 or H2 blends; and identify which existing gas transmission pipeline components may need modifications to safely introduce H2 gas or natural gas/H2 blends. *Researcher: Engineering Mechanics Corp. of Columbus* *PHMSA: $800,000*

Ongoing H_2 Pipeline Research

11 active projects totaling $10.6 million in PHMSA funding + $2.5 million in cost sharing

Project	Goals
Knowledge-guided Automation for Integrity Management of Aging Pipelines (KAI-MAP) for H_2 Transport *Category: Threat Prevention*	Develop an artificial intelligence (AI) enabled automation framework for pipeline integrity management for emerging fuels, such as H_2. 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 H_2-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 H_2 gas. Develop a publicly available software tool that operators can use to determine suitability of existing pipelines for pure H_2 or blended gas and identify needed modifications. *Researcher: University of Oklahoma* *PHMSA: $1,000,000*
Accelerating Transition towards Sustainable, Precise, Reliable H_2 Infrastructure (Super-H_2): 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 H_2 transport. *Researcher: North Dakota State University* *PHMSA: $1,000,000*
Investigate Damage Mechanisms for H_2 and H_2/Natural Gas Blends to Determine Inspection Intervals for In-Line Inspection (ILI) Tools *Category: Anomaly Detection & Characterization*	Analyze failure mechanisms related to H_2 and H_2/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*

Ongoing H_2 Pipeline Research

11 active projects totaling $10.6 million in PHMSA funding + $2.5 million in cost sharing

Project	Goals
Review of Integrity Threat Characterization Resulting from H_2 Gas Pipeline Service *Category: Climate Change*	Identify differences between existing integrity threats and possible new threats resulting from the presence of H_2. Define a list of possible changes to the ASME threat assessment process to address H_2, or H_2 blended service-based threats in new or existing pipelines. *Researcher: Engineering Mechanics Corp. of Columbus PHMSA: $240,000*
Expanding H_2 Storage to Porous Rock Formations: A Framework for Estimating Feasibility and Operational Considerations *Category: Underground Natural Gas Storage*	Develop a framework to expand underground H_2 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 H_2 movement or loss from geochemical reactions or multiphase H_2 flow with formation fluids. *Researcher: Gas Technology Institute PHMSA: $298,000*
Establishing the Technical Basis for Enabling Safe and Reliable Underground H_2 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 underground H_2 storage (UHS). Quantify the suitability of existing UGS facilities (which includes the well and subsurface geologic system) for storing pure and blended H_2. Characterize operational expectations with emphasis on quantifying risk for H_2 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*

Ongoing CO_2 Pipeline Research

2 active projects totaling $1.5 million in PHMSA funding + $380K in cost sharing

Project	Goals
Determination of Potential Impact Radius for CO_2 Pipelines using Machine Learning Approach *Category: Climate Change*	Develop a machine learning tool to predict the impact zone of accidental CO_2 releases from pipelines, improving pipeline safety assessments and emergency response. By combining simulations and machine learning, this research aims to create a rapid tool for assessing the public safety risks posed by CO_2 pipeline ruptures. *Researcher: Texas A&M Engineering Experiment Station PHMSA: $279,754*
Developing Design and Welding Requirements, Including Material Testing and Qualification of New and Existing Pipelines for Transporting CO_2 *Category: Climate Change*	Develop new design and welding requirements for pipelines transporting CO_2, ensuring their safe operation and public safety. This research will improve CO_2 pipeline safety by identifying knowledge gaps and proposing performance-based criteria for deign, materials, and operation. *Researcher: BMT Fleet Technology Limited PHMSA: $1,200,000*

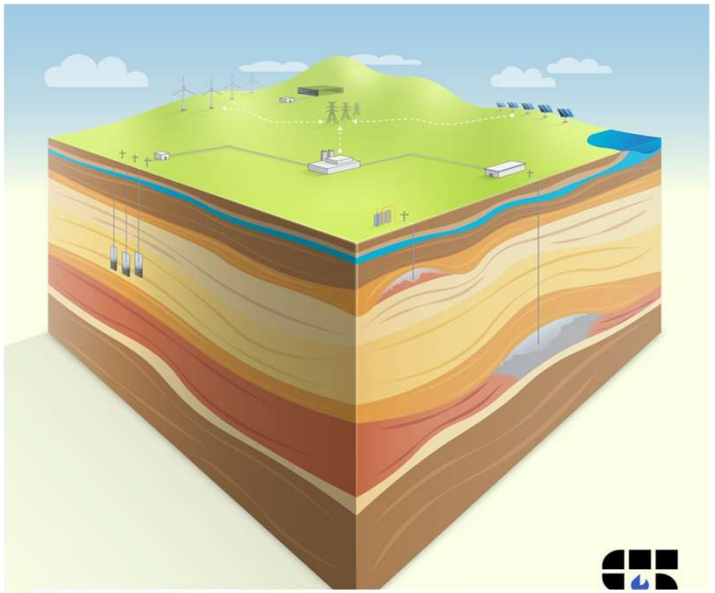
Establishing the Technical Basis for Enabling Safe and Reliable Underground H_2 Storage Operations

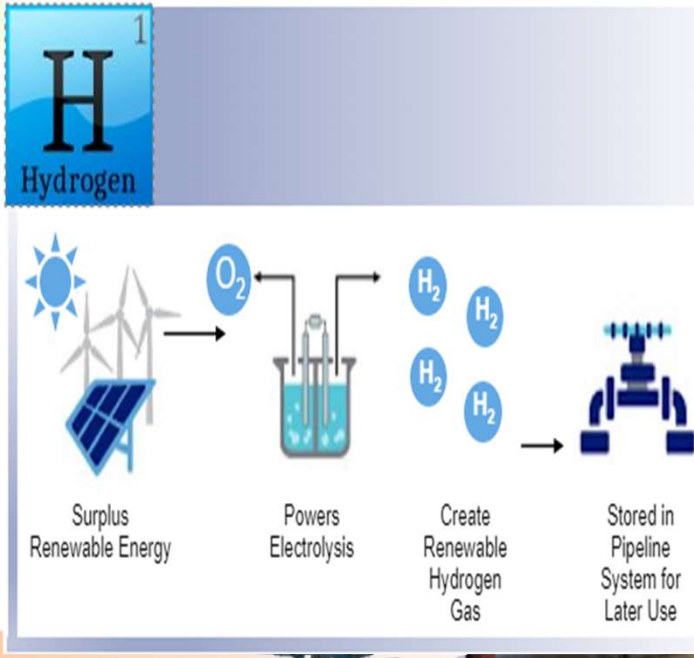
Researcher: U.S. Department of Energy, Office of Fossil Energy and Carbon Management and Subsurface H_2 Assessment, Storage, and Technology Acceleration (SHASTA) – Inter-Agency Agreement
Project Cost: $2,000,000
Public Page: https://primis.phmsa.dot.gov/matrix/PrjHome.rdm?prj=999

Project Objective: The objectives of this work are to: 1) Identify and understand existing PHMSA regulatory functions and needs as they relate to characterizing, permitting, and assessing UNGS operations within the subsurface in order to define appropriate metrics relevant to UHS; 2) Quantify the suitability of existing UGS facilities (which includes the well and subsurface geologic system) for storing pure and blended H_2; 3) Characterize operational expectations with emphasis on quantifying risk for H_2 resource loss processes, UGS asset degradation, and estimating transient behavior based on geologic and operational conditions.

Project End Date: 2/28/2025

Potential Impact on Safety: Accelerate the safe operation of UHS in the U.S. by developing guidance on how to assess the technical suitability for a particular facility to safely store H_2 or blends, characterize the operational expectations during transition or development of a facility, and scientifically inform any recommended practices or regulatory changes (with related guidance) that may be needed to support UHS.





Advancing Hydrogen Leak Detection and Quantification Technologies Compatible with Hydrogen Blends

Researcher: Gas Technology Institute
Project Cost: $1,499,070 ($749,446 PHMSA + $749,624 cost sharing)
Public Page: https://primis.phmsa.dot.gov/matrix/PrjHome.rdm?prj=979

Project Objective:

- Investigate impact of hydrogen injection on leakage dynamics.
- Investigate effect of hydrogen on existing leak detection equipment.
- Resulting analysis will inform new approaches for hydrogen sensing and integration into next-generation leak detection equipment.

Project End Date: 9/29/2025

Potential Impact on Safety: The findings will advance our understanding of hydrogen and natural gas/hydrogen blend leaks, ensuring that any leaks can be detected quickly and efficiently, reducing potential safety impacts caused by undetected leaks, and most importantly minimizing misinterpreted leak detection results causing an underestimation of the size and potential safety hazard of a leak.

Example of mobile-mounted system for natural gas detection

Example of a Handheld device

Example of a fixed-point detector

Pictures courtesy GTI

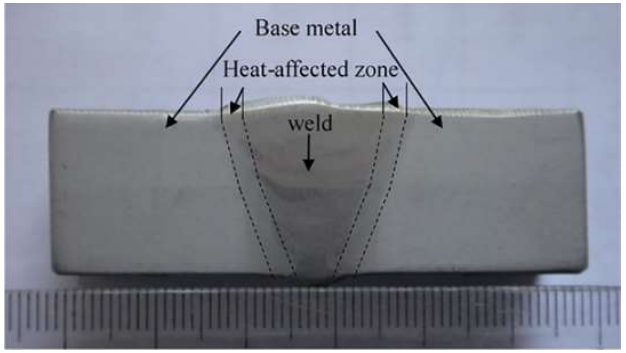
Determining Steel Weld Qualification and Performance for Hydrogen Pipelines

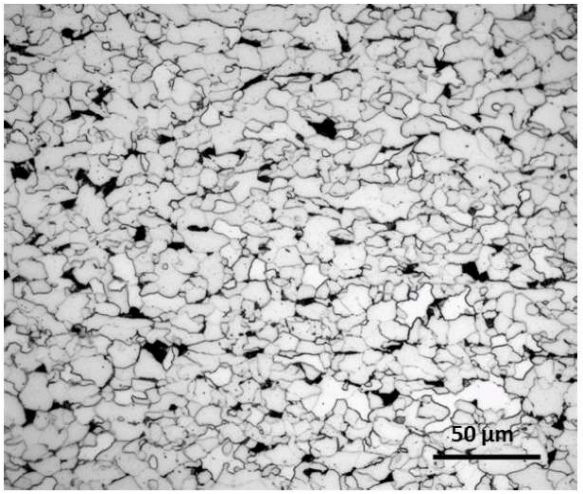
Researcher: National Institute of Standards and Technology – Inter-Agency Agreement
Project Cost: $2,060,000
Public Page:
https://primis.phmsa.dot.gov/matrix/PrjHome.rdm?prj=976

Project Objective: To review current codes and standards for gaps in qualification requirements for welds in pipelines intended for hydrogen transportation and to provide: (1) weld qualification requirements for new steel pipeline assets, including seam, girth, and repair welds; (2) performance evaluations for varying modern steel grades; and (3) assessment parameters for evaluating the integrity of existing and vintage (pre-Code) assets.

Project End Date: 9/29/2024

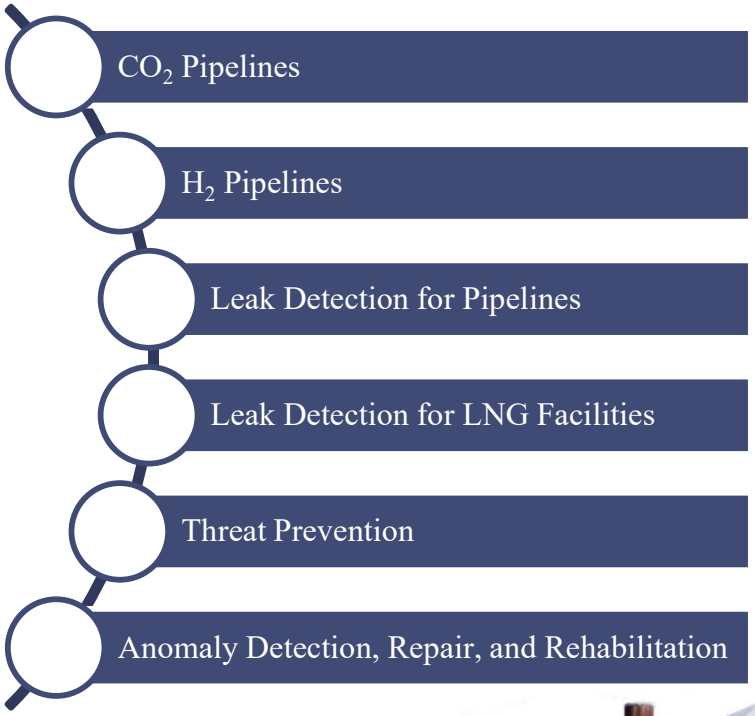
Potential Impact on Safety: An effective weld qualification procedure will support safe operation and design limits for hydrogen pipeline construction and operation.





Pipeline Safety 2023 R&D Forum

- October 31 – November 1, 2023
- Crystal City, VA
- Over 450 in-person and virtual attendees; 47 speakers
- Six working groups



Event Purpose: The purpose of the two-day R&D Forum is for public, government, and industry pipeline stakeholders to identify technology and knowledge gaps within certain topic areas. PHMSA then incorporates these areas into our research solicitations. This forum provides PHMSA leadership and staff with an opportunity to generate a national research agenda and discuss key industry and government challenges with pipeline industry stakeholders. By fostering the exchange of essential information, this discussion helps improve pipeline safety and protect the environment.

Pipeline Safety 2023 R&D Forum

Identified 5 Gaps for CO_2:

- **Gap 0** – CO_2 Specification (fundamental to all other gaps)
- **Gap 1** – Equation of State Refinement for CO_2 Pipelines
- **Gap 2** – Refine Fracture Control Models for CO_2 Pipelines
- **Gap 3** – Validate and Apply Dispersion Modeling for CO_2 Release
- **Gap 4** – Non-Metallic Materials Compatibility for CO_2 Service

Identified 4 Gaps for H_2:

- **Gap 1** – Coating and Liners Development
- **Gap 2** – Update and Validate Welding Standards for H_2 Transmission and Distribution Lines
- **Gap 3** – Evaluation of Existing Pipeline Repair and Maintenance Technologies for H_2 and H_2 -Natural Gas Blends
- **Gap 4** – Recommended Guidance for Engineering Assessment for H_2 Pipelines

Recent Research Announcements - CAAP

The CAAP Program closed a Notice of Funding Opportunity on May 17, 2024, which included the following three topics:

- **Characterize Expected CO_2** Specification Ranges for Various Product Streams.
- Design a Modernized Database to Integrate Publicly Available Climate- and **Geohazard-Related Data** into Existing Database Used for All Pipelines.
- Enhance Current Knowledge and Technology Solutions to Prevent and Mitigate Risks of **Stress Corrosion Cracking (SCC)** for Pipeline Integrity Management.

Recent Research Announcements - Core

The Core program closed a research announcement on June 14, 2024, soliciting projects on 14 topics in the following areas:

- **CO_2 and H_2 Pipeline Safety**: Three topics focused on CO_2 characterizations, H_2 line repair technologies, and risk modeling of H_2 systems.
- **Leak Detection**: Three topics, including all system types focused on improving locating technology, improved speed and quantification, and validation of existing technology.
- **LNG**: Two topics focused on gap analysis for leak detection and repair program and consequences of LNG storage tank failure.
- **Threat Prevention**: Three topics, including all system types focused on strain demand, conversion and repurposing pipeline threats, and improving training methods for emergency response.
- **Anomaly Detection and Characterization**: Two topics, including all system types focused on pipe and weld toughness and improving repair coatings or liners.
- **Hazardous Liquid Tanks**: One topic focused on volatile corrosion inhibitors.

Proposals for these announcements are still under review and awards will be granted in the coming months.

Current and Future Planning Initiatives

- H_2 Interagency Taskforce
  - ❖ Collaboration among federal agencies to further advance the national clean hydrogen strategy.
  - ❖ R&D staff participate in working groups and crosscutting teams under this initiative.

- R&D Forum in the Fall of 2025
  - ❖ Share ideas and gaps!

https://primis.phmsa.dot.gov/rd/gapsuggestions.htm

Or email: R&Dteam@dot.gov

R&D Links

Scan or click here to subscribe for email updates.

Scan or click here to learn more about PHMSA's Pipeline Safety Research Program.

Scan or click here to visit project pages Summarizing the funded research.

Scan or click here to see the past R&D project results.

Scan or click here to learn more about PHMSA's grants and funding opportunities.

Scan or click here to learn more about the Office of Pipeline Safety.

THANK YOU!

Pipeline Safety

Max Kieba
Director, OPS Engineering and Research
E-mail: max.kieba@dot.gov

Kandilarya "Kandi" Barakat
Operations Supervisor, Research and Development
E-mail: kandilarya.barakat@dot.gov