Pipeline and Hazardous Materials Safety Administration

Office of Pipeline Safety

Hydrogen Gas: Pipeline Safety and Research & Development Program

Vincent Holohan & Robert Smith

Bulk Storage of Gaseous Hydrogen Workshop

February 10, 2022

PHMSA and Pipeline Safety

PHMSA's Mission

PHMSA's mission is to protect people and the environment by advancing the safe transportation of energy and other hazardous materials that are essential to our daily lives.

By the Numbers

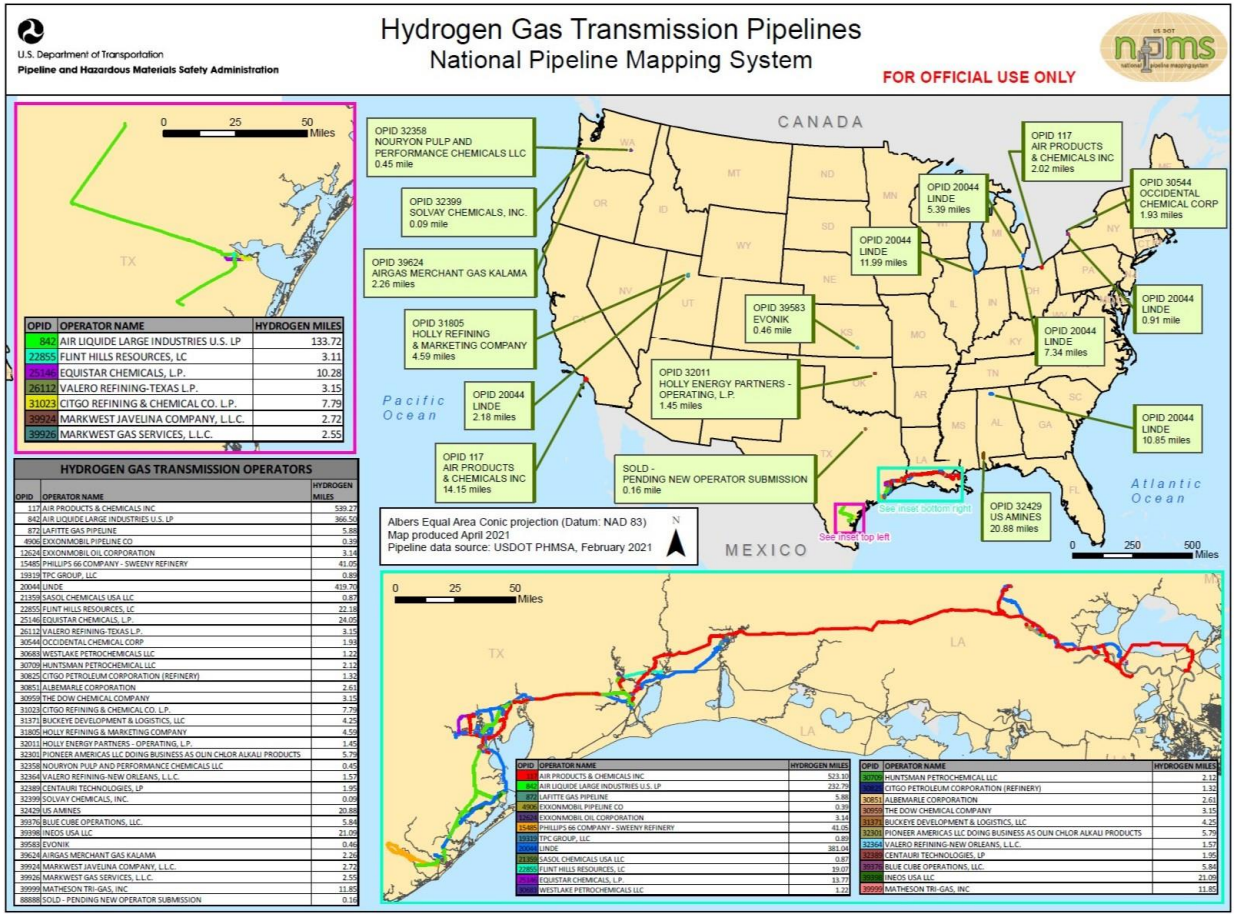
2.8 Million
Miles of Regulated Pipelines

17,000
Underground Natural Gas Storage Wells

64%
of U.S. Energy Commodities Transported by Pipeline

Hydrogen Gas Pipelines

Hydrogen Gas Transmission Map



OPID	OPERATOR NAME	HYDROGEN MILES
842	AIR LIQUIDE LARGE INDUSTRIES U.S. LP	133.72
22855	FLINT HILLS RESOURCES, LC	3.11
25146	EQUISTAR CHEMICALS, L.P.	10.28
26112	VALERO REFINING-TEXAS L.P.	3.15
31023	CITGO REFINING & CHEMICAL CO. L.P.	7.79
39924	MARKWEST JAVELINA COMPANY, L.L.C.	2.72
39926	MARKWEST GAS SERVICES, L.L.C.	2.55

HYDROGEN GAS TRANSMISSION OPERATORS

OPID	OPERATOR NAME	HYDROGEN MILES
117	AIR PRODUCTS & CHEMICALS INC	589.27
842	AIR LIQUIDE LARGE INDUSTRIES U.S. LP	366.50
872	LAFITTE GAS PIPELINE	5.88
4906	EXXONMOBIL PIPELINE CO	0.39
12624	EXXONMOBIL OIL CORPORATION	3.14
15485	PHILLIPS 66 COMPANY - SWEENY REFINERY	41.05
19319	TPC GROUP, LLC	0.89
20044	LINDE	419.70
21359	SASOL CHEMICALS USA LLC	0.87
22855	FLINT HILLS RESOURCES, LC	22.18
25146	EQUISTAR CHEMICALS, L.P.	24.05
26112	VALERO REFINING-TEXAS L.P.	3.15
30544	OCCIDENTAL CHEMICAL CORP	1.93
30683	WESTLAKE PETROCHEMICALS LLC	1.22
30705	HUNTSMAN PETROCHEMICAL LLC	2.12
30825	CITGO PETROLEUM CORPORATION (REFINERY)	1.32
30851	ALBEMARLE CORPORATION	2.61
30959	THE DOW CHEMICAL COMPANY	3.15
31023	CITGO REFINING & CHEMICAL CO. L.P.	7.79
31377	BUCKEYE DEVELOPMENT & LOGISTICS, LLC	4.25
31805	HOLLY REFINING & MARKETING COMPANY	4.59
32011	HOLLY ENERGY PARTNERS - OPERATING, L.P.	1.45
32301	PIONEER AMERICAS LLC DOING BUSINESS AS OLIN CHLOR ALKALI PRODUCTS	5.79
32358	NOURYON PULP AND PERFORMANCE CHEMICALS LLC	0.45
32364	VALERO REFINING-NEW ORLEANS, L.L.C.	1.57
32389	CENTAURI TECHNOLOGIES, LP	1.95
32399	SOLVAY CHEMICALS, INC.	0.09
32429	US AMINES	20.88
39376	BLUE CUBE OPERATIONS, LLC.	5.84
39398	INEOS USA LLC	21.09
39583	EVONIK	0.46
39624	AIRGAS MERCHANT GAS KALAMA	2.26
39924	MARKWEST JAVELINA COMPANY, L.L.C.	2.72
39926	MARKWEST GAS SERVICES, L.L.C.	2.55
39999	MATHESON TRI-GAS, INC	11.85
88888	SOLD - PENDING NEW OPERATOR SUBMISSION	0.16

Hydrogen Gas Transmission Mileage

	Calendar Year	Interstate Miles	Intrastate Miles	Total Miles
Hydrogen Gas	2020	796.4	759.8	1556.2
	2019	778.9	758.7	1,537.6
	2018	772.6	726.8	1,499.3
	2017	772.5	727.4	1,499.9
	2016	827.2	784.5	1,611.7
	2015	780.5	785.5	1,566.0
	2014	782.8	777.4	1,560.2
	2013	781.5	770.2	1,551.7
	2012	729.6	782.3	1,511.9
	2011	380.5	966.3	1,346.8
	2010	374.9	992.6	1,367.5

Current Transportation Regulations

49 CFR Part 192 Regulations Unique to Hydrogen Gas Pipelines

- PHMSA has regulated the transportation of Hydrogen gas by pipeline since 1970
- Limited regulatory differences between Hydrogen and Natural Gas pipeline transportation
- Blends are not currently defined or specifically captured in data
- § 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
- § 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"

PHMSA Hydrogen Pipeline Research

Project Title	Summary
Performance Evaluation of High-Strength Steel Pipelines for High-Pressure Gaseous Hydrogen Transportation ($659,500)	The project conducted a fatigue and fracture-toughness property testing and collected data on crack initiation, crack propagation, and final failure.
Cost-Effective Techniques for Weld Property Measurement and Technologies for Improving Weld Hydrogen Embrittlement and Intergranular Stress Corrosion Cracking Resistance for Alternative Fuel Pipelines ($665,211)	The project conducted destructive material testing to collect data to better understand the relationship among composition, microstructure, and fatigue resistance. It compared welds to the base metal. This included characterization of the crack tip and the influence of hydrogen on deformation behavior around the crack tip.
The Effect of Pressurized Hydrogen Gas on the Fatigue Properties of the Heat-Affected Zones in X52 and X70 Pipelines ($160,000)	The project investigated heat-affected zones that may behave differently in a hydrogen gas environment.
The Effect of Pressurized Hydrogen Gas on the Fatigue Properties of Welds in X52 and X70 Pipelines ($105,187.35)	The project investigated welds that may behave differently in a hydrogen gas environment.
Knowledge-guided Automation for Integrity Management of Aging Pipelines (KAI-MAP) for Hydrogen Transport ($844,726)	The project is developing an Artificial Intelligence enabled automation framework for pipeline safety data collection and processing to support integrity decision making of pure hydrogen pipelines.

Background

PHMSA's Pipeline Safety Research Program & Related Research To Date

Pipeline Safety Research Program 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**.

Related Research Impacts To Date

- $2.3 Million in knowledge-based H_2 research with a heavy focus on materials and welding qualifications
- Project final reporting provides information about the issues covered, with several papers published
- Knowledge Transfer registered to standards bodies
  - American Society of Mechanical Engineering B31.12 Standard on Hydrogen Piping and Pipeline

All reporting searchable & available via:

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

2021 R&D Forum Output

Hydrogen Gaps/Topics

Pipeline Transportation: Hydrogen and Emerging Fuels R&D Public Meeting and Forum

Event Purpose: Assist PHMSA in developing its R&D agenda for the next two years and help address one of DOT's strategic goals to develop climate solutions. The first day of the event was a public meeting and general session focusing on two objectives: **(1)** The current state of PHMSA's pipeline safety R&D; and **(2)** The environmental and infrastructure impacts of a shift to clean emerging fuels. The second day consisted of six smaller interactive working groups to develop robust R&D topics for funding consideration by PHMSA. The final day included a report out from each working group.

Event Summary:

- Nov 30th - Dec 2nd, 2021
- Approximately 530 virtual attendees
- 25 research gap/topics identified as a priority for future research
- 13 hydrogen related research gaps/topics identified in 3 working groups
- All presentations are available here:
  https://primis.phmsa.dot.gov/meetings/MtgHome.mtg?mtg=153

H_2 Research Gaps

Technology Development

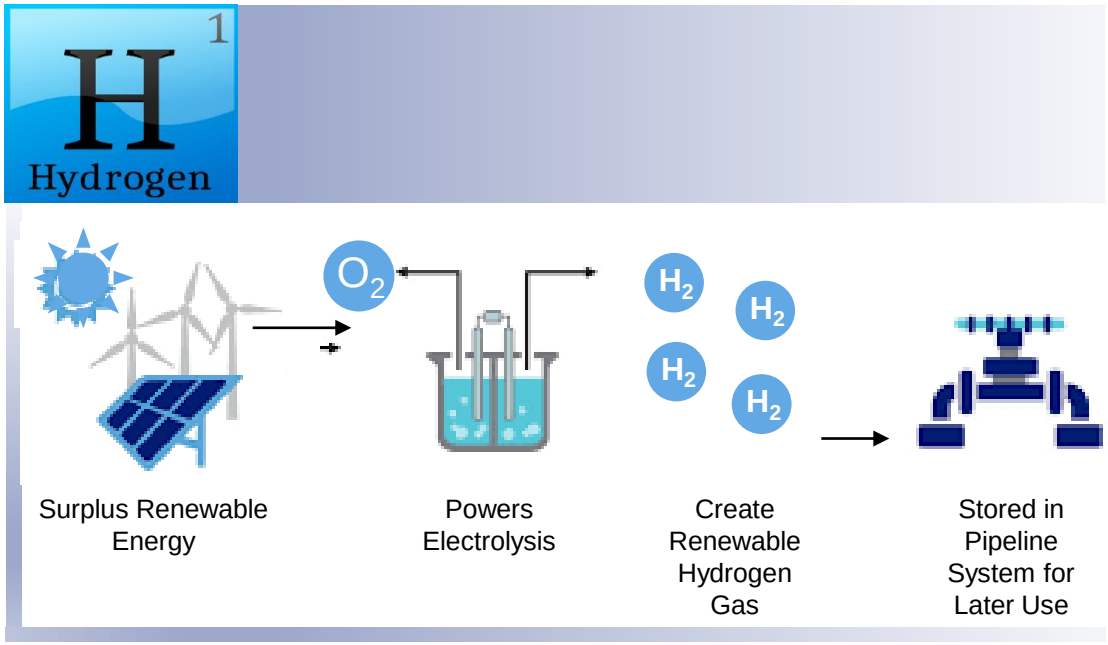
Solutions for Predicting / Monitoring Hydrogen Gas Loss

General Knowledge

Review of Integrity Threat Characterization Resulting from Hydrogen Gas Pipeline Service

Technology Development

Advancing Hydrogen Gas Leak Detection Tools when Blended with Natural Gas Pipeline Operations



General Knowledge

Determining the Required Modifications to Safely Repurpose Existing Pipelines to Transport Blended & Pure Hydrogen

Technology Development

Validate Existing or Develop New Hydrogen Leak Detection Sensors Compatible with Hydrogen-Natural Gas Blends

Next Steps

Soliciting the Hydrogen Research Agenda

Since the Forum:

- Reviewed and considered all stakeholder input and presentation materials
- Drafted comprehensive research topics
- PHMSA Leadership Review
- Winter/Spring posting of Research Solicitation
- New research awards by September 2022

SBIR · STTR
America's Seed Fund

Thank You

Robert Smith
Senior R&D Program Manager
Department of Transportation
Pipeline & Hazardous Materials
Safety Administration
Office of Pipeline Safety
(919) 238-4759
robert.w.smith@dot.gov

Vincent Holohan
Senior Engineer
Department of Transportation
Pipeline & Hazardous Materials
Safety Administration
Office of Pipeline Safety
(202) 360-6615
vincent.holohan@dot.gov