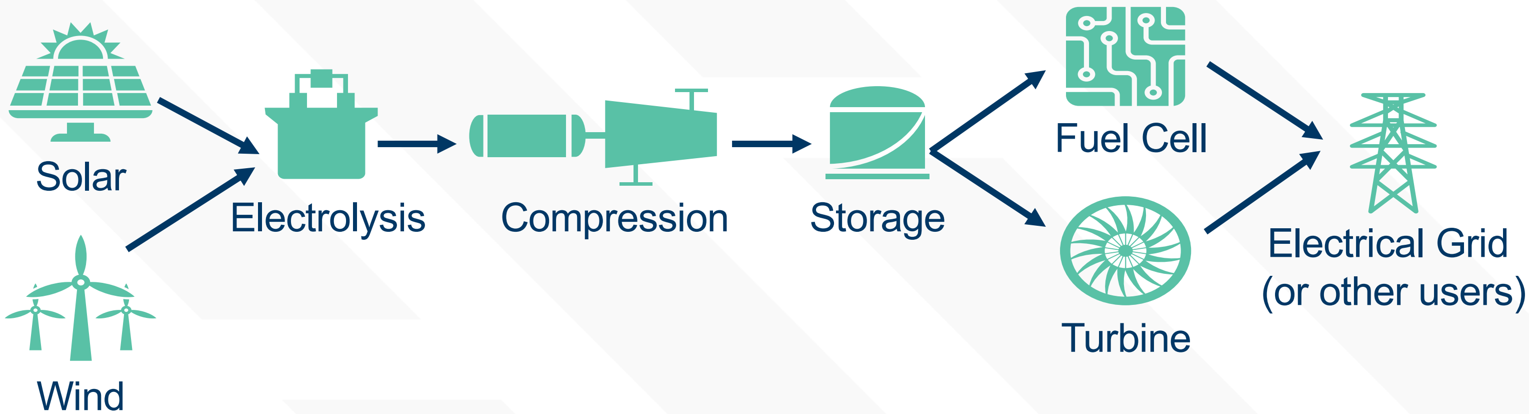
Pipeline Considerations for New and Repurposed Pipelines:

Conversion for Pure H_2 Pipelines and Blended NG/H_2 Pipelines

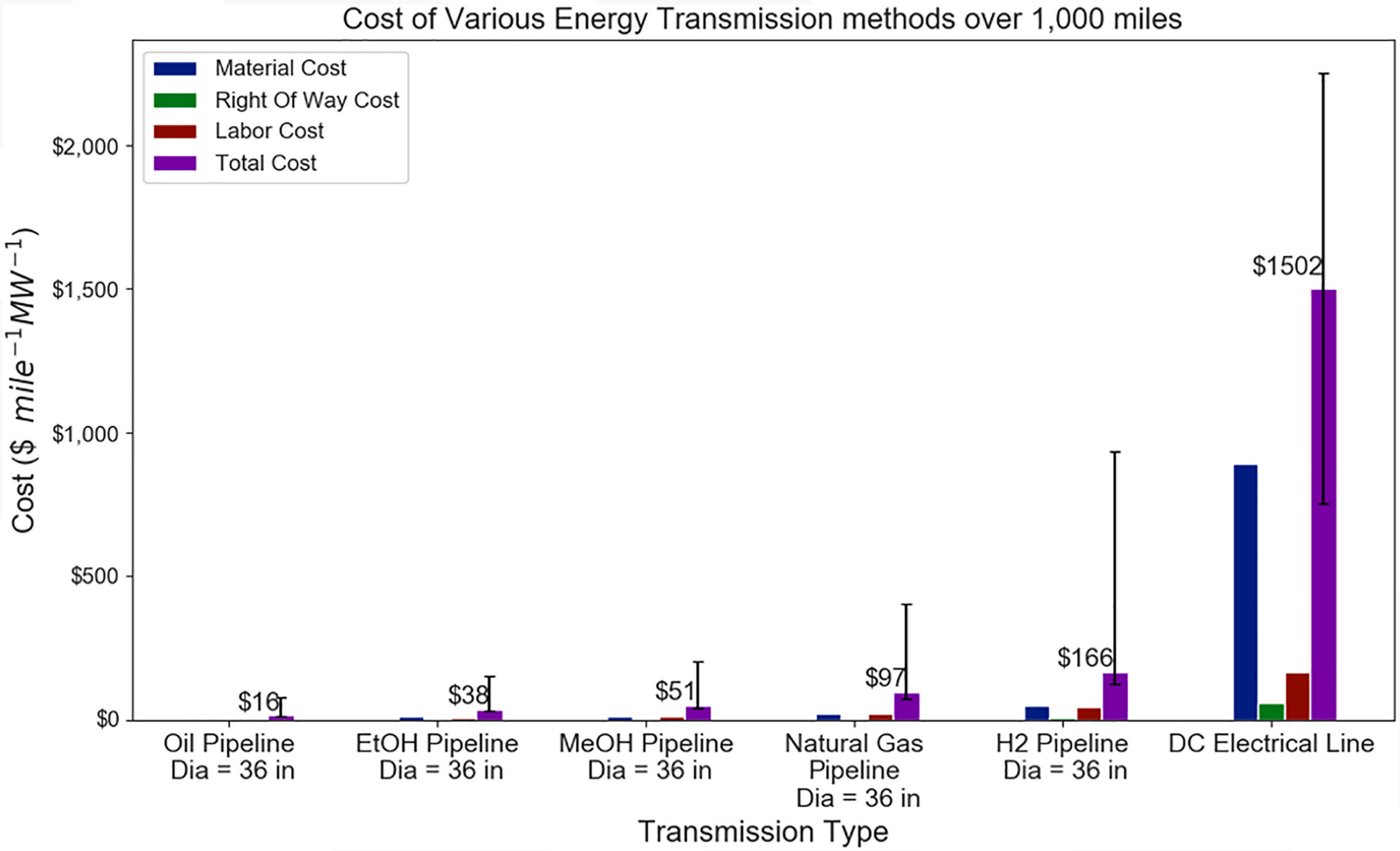
Speaker: Andrew López
Company: Burns & McDonnell

Summary

- Guidance for introducing hydrogen into pipelines
- ASME B31.12-2019 & ASME B31.8-2022 for hydrogen systems
- Inspection, testing, and anomalies
- Wall thickness determination and MAOP



Is this guy at the wrong conference?



Relevant Code

- ASME B31.8-2022 for hydrogen in hydrocarbon mixtures
  - No upper limit in code, but pure H_2 excluded in scope
  - ASME B31.8 is incorporated by reference in 49 CFR Part 192 [1]
- ASME B31.12-2019 for pure hydrogen
  - Minimum 10% hydrogen
  - More conservative calculations
- Clarifications on code scope within ASME B31 Committee

The American Society of Mechanical Engineers

Conversion of Existing Pipelines

- Behavior of blended hydrogen systems
- Hydrogen-induced damage factors

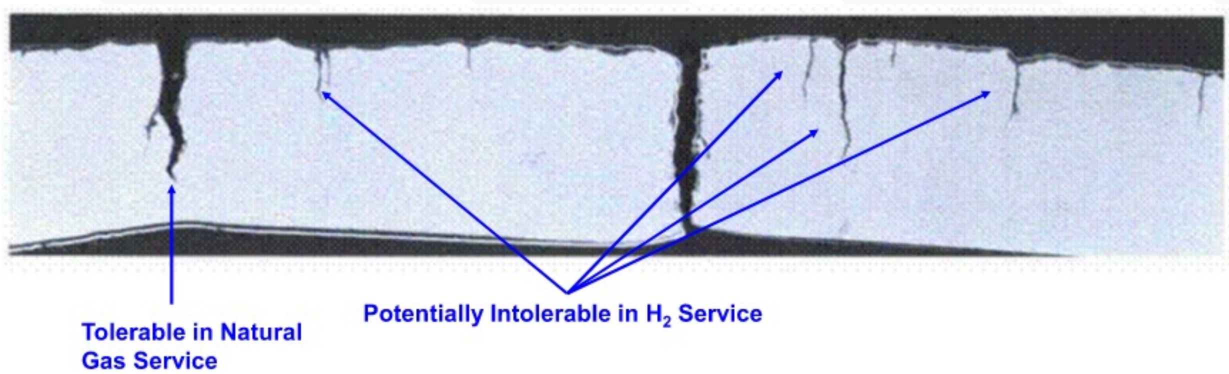
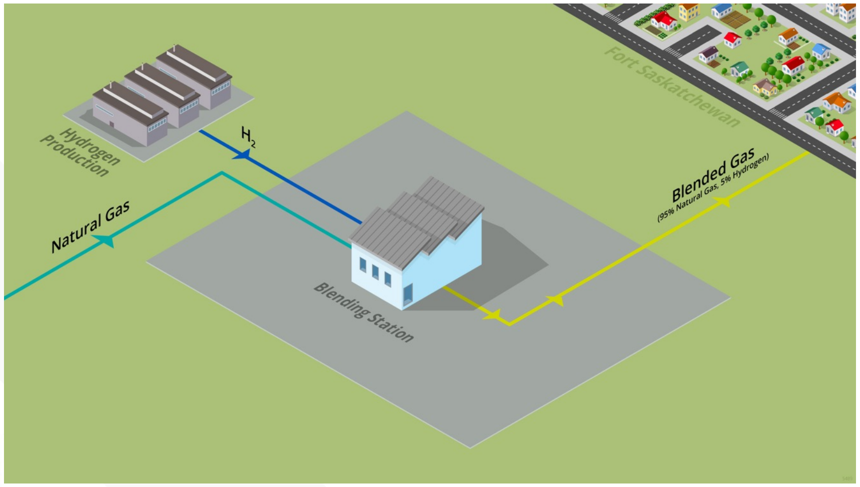


*Image courtesy of Ken Lee (DNV GL), permission provided via email Friday, August 4, 2023 2:13 pm

Blended Hydrogen Systems

- ▶ Safety evidence for up to 25% hydrogen*
- ▶ Grades suitable for blended hydrogen
- ▶ Anomaly identification through smart pigging



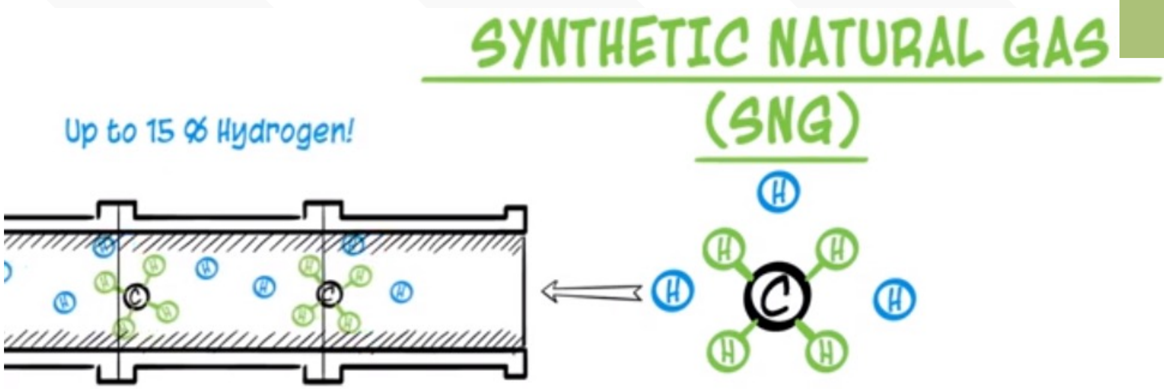
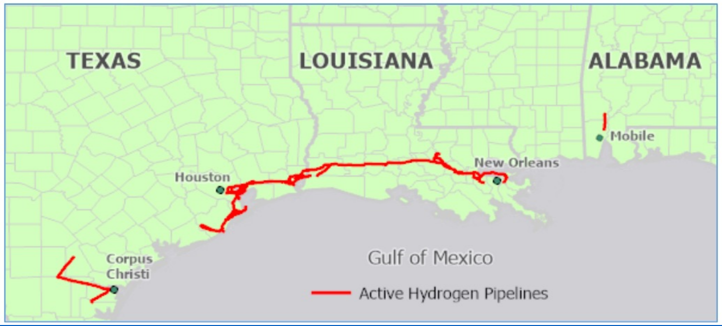
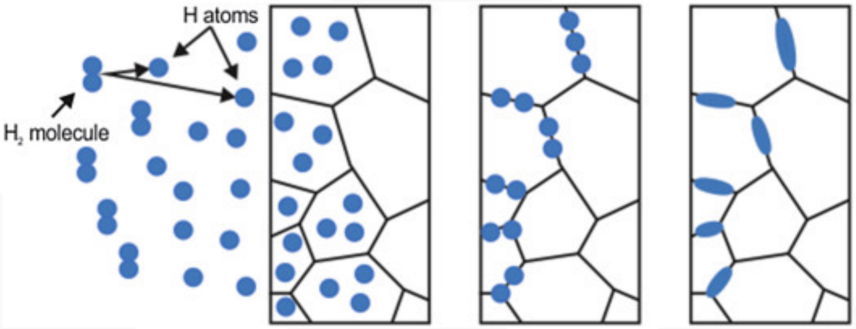


Image credits
Hawai'I Gas: https://www.youtube.com/watch?v=KDG1hBQt-eA&t=1s
ATCO: https://gas.atco.com/content/dam/web/projects/projects-overview/hydrogen/FtSask-Blending-Project3-1280x720.jpg

Pure Hydrogen Systems

- ► Hydrogen embrittlement/attack
- ► Inspection and anomaly records
- ► All threaded and flanged connections should be inspected for potential leaks.
- ► Existing or historic pipeline defects that can be embrittled by H2
  - Axial cracks
  - Circumferential cracks
  - Internal surface-breaking defects
  - Pipe seam defects, e.g., hook cracks and lack of weld seam fusion
  - Hard spots
  - Welds with defects or high hardness





[9] Del-Pozo, Villalobos, Serna

Material Specifications & Selection

- Metallurgical reactions with hydrogen
- Lower-grade materials for prevention
- Piping material performance factor (Mf)
- Pipeline material performance factor (Hf)

Table IX-5B Carbon Steel Piping Materials Performance Factor, M_f

Specified Min. Strength, ksi		System Design Pressure, psig					
Tensile	**Yield**	**≤1,000**	**2,000**	**3,000**	**4,000**	**5,000**	**6,000**
70 and under	≤52	1.0	0.948	0.912	0.884	0.860	0.839
Over 70 through 75	≤56	0.930	0.881	0.848	0.824	0.800	0.778
Over 75 through 80	≤65	0.839	0.796	0.766	0.745	0.724	0.706
Over 80 through 90	≤80	0.715	0.678	0.645	0.633	0.618	0.600

Specified Min. Strength, ksi		System Design Pressure, psig					
Tensile	**Yield**	**≤1,000**	**2,000**	**2,200**	**2,400**	**2,600**	**2,800**	**3,000**
66 and under	≤52	1.0	1.0	0.954	0.910	0.880	0.840	0.780
Over 66 through 75	≤60	0.874	0.874	0.834	0.796	0.770	0.734	0.682
Over 75 through 82	≤70	0.776	0.776	0.742	0.706	0.684	0.652	0.606
Over 82 through 90	≤80	0.694	0.694	0.662	0.632	0.610	0.584	0.542

Table PL-3.7.1-2 Basic Design Factor, *F* (Used With Option B)

Location Class	Design Factor, *F*
Location Class 1, Division 2	0.72
Location Class 2	0.60
Location Class 3	0.50
Location Class 4	0.40

Table PL-3.7.1-3 Temperature Derating Factor, *T*, for Steel Pipe

Temperature, °F	Temperature Derating Factor, *T*
250 or less	1.000
300	0.967
350	0.933
400	0.900
450	0.867

GENERAL NOTE: For intermediate temperatures, interpolate for derating factor.

Example Calculations

- ▶ Wall thickness calculations for various grades
- ▶ ASME B31.12 vs. ASME B31.8
  - B31.12 has separate calculations for piping and pipelines

Table 1 – B31.12 Wall Thickness for 42" Piping @ 1400 psig up to 300 °F

Grade	Wall Thickness
X42	1.535”
X52	1.399”
X56	1.397”
X60	1.456”
X65	1.426”
X70	1.571”
X80	1.434”

Table 3 - B31.12 Wall Thickness for 42" Pipeline @ 1400 psig up to 300 °F

Grade	Wall Thickness
X42	2.195”
X52	2.014”
X56	2.127”
X60	2.027”
X65	2.200”
X70	2.084”
X80	2.117”

Table 5 - B31.8 Wall Thickness for 42" Pipe @ 1400 psig up to 300 °F

Grade	Wall Thickness
X42	1.167”
X52	0.9423”
X56	0.875”
X60	0.817”
X65	0.754”
X70	0.700”
X80	0.613”

Calculations, continued

- Wall thickness calculations for various grades
- ASME B31.12 vs. ASME B31.8
  - B31.12 has separate calculations for piping and pipelines

Table 2 - B31.12 Wall Thickness for 30" Piping @ 1400 psig up to 300 °F

Grade	Wall Thickness
X42	1.096"
X52	0.999"
X56	0.998"
X60	1.046"
X65	1.019"
X70	1.122"
X80	1.024"

Table 4 - B31.12 Wall Thickness for 30" Pipeline @ 1400 psig up to 300 °F

Grade	Wall Thickness
X42	1.568"
X52	1.439"
X56	1.519"
X60	1.448"
X65	1.572"
X70	1.489"
X80	1.512"

Table 6 - B31.8 Wall Thickness for 30" Pipe @ 1400 psig up to 300 °F

Grade	Wall Thickness
X42	0.834"
X52	0.674"
X56	0.625"
X60	0.584"
X65	0.539"
X70	0.500"
X80	0.438"

Seriously? More…

► Repurposing a 1400 psig Natural Gas line

Table 6 - B31.8 Wall Thickness for 30" Pipe @ 1400 psig up to 300 °F

Grade	Wall Thickness
X42	0.834"
X52	0.674"
X56	0.625"
X60	0.584"
X65	0.539"
X70	0.500"
X80	0.438"

→ 430 psig

Table 5 - B31.8 Wall Thickness for 42" Pipe @ 1400 psig up to 300 °F

Grade	Wall Thickness
X42	1.167"
X52	0.9423"
X56	0.875"
X60	0.817"
X65	0.754"
X70	0.700"
X80	0.613"

→ 430 psig

Conclusion

- Blending hydrogen in existing pipelines up to 25%
- Analysis for pure hydrogen conversion
- Considerations for new hydrogen pipelines

- Keywords
  - Hydrogen Pipelines
  - Blended Natural Gas
  - Net Zero Carbon Economy

Q&A

BURNS McDONNELL℠