



energy to inspire the world

# H2 pipelines? Not a new issue

## The SNAM experience

6<sup>th</sup> AIEE Energy Symposium

G. Annoni, L. Bacchi (\*), M. Crespi

# Initial questions



**Why H<sub>2</sub>?**

**Why H<sub>2</sub> in Europe?**

**Why H<sub>2</sub> in Italy?**

**Can new steel pipelines be built for H<sub>2</sub> transmission?**

**Can existing steel pipelines be converted to H<sub>2</sub> transmission?**

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# The context: why hydrogen?

-  • goal of net zero emissions by 2050
-  • green hydrogen (produced from renewable sources) is rapidly becoming competitive:
  - because the cost of renewables – especially solar – is falling rapidly
  - improvements in electrolysis technology
-  • green hydrogen may become competitive with fossil fuels in some application
-  • blue hydrogen could decrease the time to reduce emissions in so-called hard-to-abate sectors (refineries, steel mills, etc.) with high thermal energy consumption
-  • hydrogen can be used for heavy transport, electricity production and heating

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# The context: why hydrogen?



- the current demand for decarbonized sustainable energy gives to hydrogen a very important role



- hydrogen it's a very strategic solution because of the availability in Europe of already existing pipelines operated with natural gas that can be rehabilitated to hydrogen transmission



- the "repurposing" of existing transport infrastructure requires investments between 10% and 25% of the cost for building a dedicated infrastructure from scratch



European natural gas transmission network  
(source: ENTSOG – European Network of Transmission Operators for Gas).

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# The Italian context



- with over 32000 km of operating pipelines, Snam has the largest and most interconnected gas network in Europe



- the Italian network receives natural gas from Russia, Northern Europe, Algeria, TAP and is connected to three regasification plants



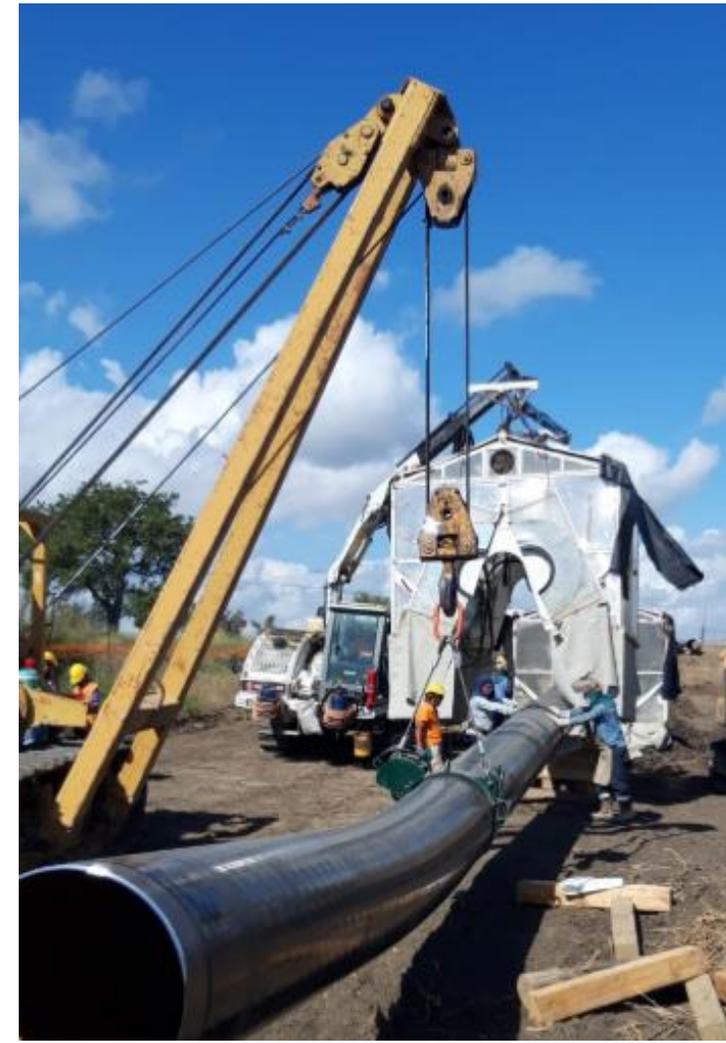
- the geographical position of connection between North Africa and continental Europe can allow Italy to become an important transmission channel of green hydrogen produced from solar sources in the country and in North Africa to other European countries



# The Italian context



- Snam pipelines main characteristics:
  - diameter up to 1400 mm
  - maximum internal pressure up to 75 bar
  - steel grade up to API 5L X65



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# Hydrogen pipelines



- carbon steel has been used for the transportation and storage of hydrogen for over a hundred years



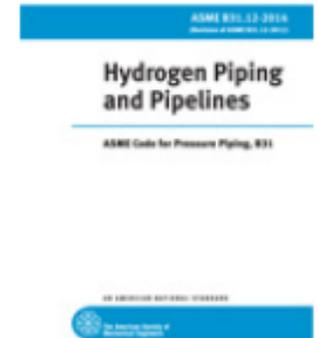
- nowadays more than 4500km of hydrogen pipelines are in operation worldwide



- the use of carbon steel pipelines to carry hydrogen is not a new issue



- a technical standard (ASME B.31.12) is already available for hydrogen pipelines (H<sub>2</sub> between 10% and 100% in volume) with the technical rules for
  - the design of new hydrogen pipelines
  - the rehabilitation of existing pipelines.



# ASME B.31.12



- steel grade up to X80 according to API 5L (minimum guaranteed yield strength for X80 is 555MPa)



- higher is the steel grade, more restrictive are the requirements imposed by the standard, in order to properly consider the potential different effects of hydrogen on steels with different microstructures and mechanical properties



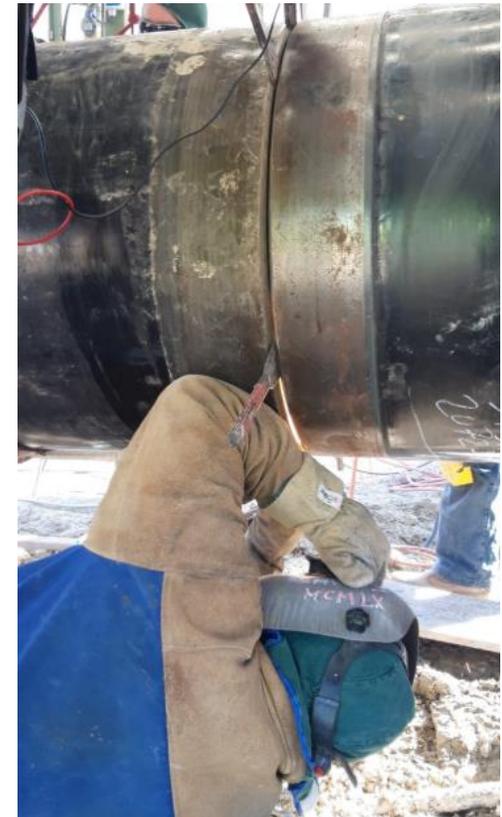
- the technical standards takes properly in account the effects of the atomic hydrogen on the carbon steel in all the possible operating conditions of a transmission pipeline (different levels of stresses, loading cycles, etc) and impose consequently technical requirements as a function of these specific conditions



- the conversions criteria assure the same high levels of safety and reliability of the assets currently operated with natural gas. That means that no changes are expected in terms of probability of failure of the existing assets.



- two main options for the design/repurposing criteria:
  - option A
  - option B



# ASME B.31.12



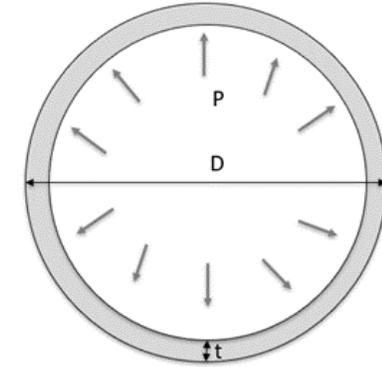
## • Option A

- no specific material characterizations
- low levels of circumferential stress due to the imposition of a maximum design factor F (0.5 or 0.4 depending on steel grade)
- performance factor Hf function of the steel grade



## • Option B

- higher level of circumferential stress in the pipe due to the internal pressure, up to a value of 72% of the yielding stress (maximum design factor F=0.72)
- In order to avoid potential effects due to the presence of hydrogen, a minimum level of material toughness in environment with molecular hydrogen is required



Barlow's formula

$$\sigma = \frac{PD}{2t}$$

ASME B.31.12 formula

$$P = \frac{2St}{D} F E T H_f$$

D = nominal outside diameter of pipe  
E = longitudinal joint factor  
F = design factor  
Hf = material performance factor  
P = design pressure  
T = temperature derating factor  
t = nominal wall thickness

# Not only ASME B.31.12



- many studies and experimental research projects are ongoing in order to put together the best practices and to build new and updated guidelines (reliable, practical and not over conservative) for the conversion to hydrogen of the existing pipelines.



- an ad hoc European technical standard is looked for by the industry in order to harmonize these approaches also in a European technical reference



- if from a point of view there are already available technical standards for the design and repurposing of H2 pipelines, at the same time there are some ongoing activities that could enable more practical approaches especially in case of repurposing of long existing pipelines and networks according to methods based on option B approach (material characterization Vs H2)



# Snam pipelines hydrogen readiness



- new pipelines:
  - in 2020 Snam issued a revision of its internal standards for the supply of pipes for the construction of new gas pipelines in order to fully meet the requirements of ASME B31.12 option B
  - in June 2021, a first batch of 440 km of HFW pipes (grade L415ME) was produced for Snam according to this standard, with an external diameter of 26" and thicknesses of 11.1 mm and 15.9 mm. The pipes will be able to carry hydrogen (up to 100%) with the MAOP of 75 bar



# Snam pipelines hydrogen readiness



- existing pipelines:

- Snam started an assessment of the compatibility with the transport of hydrogen (up to 100%) of each operating pipeline in its network: starting from the technical characteristics of the pipelines (steel grade, MAOP, thickness, diameter, etc.), and in full compliance with the current provisions of ASME B31.12 Option A standard
- To date, almost the entire network has been verified by Snam and the perimeter analyzed is compatible with the transport of hydrogen, albeit with a reduction in MAOP (compared to the use with natural gas) in 25-30% of cases
- the verification of the compatibility with the transport of H<sub>2</sub>, the recalculation of the MAOP and any requirements for the adaptation of the accessory components (for example, of the instrumentation) of each individual pipeline will also be subjected to certification carried out by a third-party certification body



# Snam pipelines hydrogen readiness



- existing pipelines, next steps:
  - definition of new requirements for the application of option B to complex pipelines networks
  - re-assessment, according to option B, of pipelines with a MAOP reduction according to option A
  - Snam has already started to test some of its existing pipelines, by cutting some pipes and performing on specimens made from base and weld materials tests in hydrogen



# Conclusions



- with over 4200 km of hydrogen pipelines already in operation worldwide, the use of carbon steel pipelines to transport hydrogen is not a new issue



- new steel pipelines can be designed for hydrogen transmission and existing steel pipelines, today operating with natural gas, can be converted to hydrogen transmission



- the technical references for that are already available and some further developments will be able to introduce also more practical approaches for the reconversion



- Snam, according to the ASME B.31.12, has already formalized the requirements for new pipelines for hydrogen transmission and for the characterization (maximum allowable operating pressure) of the operating conditions for the conversion of the existing pipelines





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