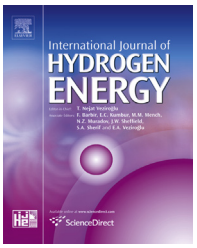
INTERNATIONAL JOURNAL OF HYDROGEN ENERGY XXX (2016) 1–15

Available online at www.sciencedirect.com

ScienceDirect

journal homepage: www.elsevier.com/locate/he



Review Article

Hazards, safety and knowledge gaps on hydrogen transmission via natural gas grid: A critical review

Zine labidine Messaoudani [a], *Fotis Rigas* [b], *Mahar Diana Binti Hamid* [a,*], *Che Rosmani Che Hassan* [a]

[a] *Chemical Engineering Department, Faculty of Engineering, University of Malaya, 50603 UM Kuala Lumpur, Malaysia*

[b] *School of Chemical Engineering, National Technical University of Athens, 15780 Athens, Greece*

ARTICLE INFO

Article history:
Received 29 April 2016
Received in revised form
15 July 2016
Accepted 19 July 2016
Available online xxx

Keywords:
Hydrogen
Natural gas
Pipeline
Hazards
Safety measures
Knowledge gaps

ABSTRACT

In the last decade significant concern is growing regarding greenhouse gas emissions, global warming and fuel scarcity. Thus, the need arises to implement a new energy carrier that could provide the same energy value and contribute to reducing carbon dioxide emissions. Hydrogen has the potential to be this energy carrier and is becoming more popular. In the near future hydrogen will be produced in large quantities and will certainly need to be transported for a long distances. Given that the world is moving toward green energy, and in order to shorten the transition period and for economic and safety reasons, the use of the existing natural gas transportation grid is the best option. Since the physical and chemical properties of hydrogen and natural gas are different, the injection of hydrogen into natural gas pipeline grid will engender different hazards that are neither all known nor understood. Hydrogen technology must ensure the same safety level as hydrocarbon technology before authorising the interaction with stakeholders and the public. This paper provides a brief summary of the main known hazards and risks associated with hydrogen injection into a natural gas grid and the latest progress in safety measures, the knowledge gaps and future research.

Contents

* *Corresponding author.*
E-mail address: mahar.diana@um.edu.my (M.D. Binti Hamid).

http://dx.doi.org/10.1016/j.ijhydene.2016.07.171
0360-3199/

Nomenclature

H_2	Hydrogen
H_2O	Water
NG	Natural gas
CH_4	Methane
CO	Carbon monoxide
CO_2	Carbon dioxide
CCS	Carbon capture and storage
QRA	Quantitative risk assessment
TNT	Trinitrotoluene
ATEX	Explosive atmosphere
LOC	Limiting oxygen for combustion
λ	The hydrogen content of the fuel
FL	Flammability limits
SOP	Standard operating procedures
D	Damage
D_p	The population density
A	The involved area
V_c	The vulnerability coefficient
r_{exp}	Hazard distance from explosion, m
r_{fire}	Hazard distance from the center of jet flame, m
α	Ratio of effective hole area to pipe cross-sectional area, dimensionless
d	Pipeline diameter, m
P_0	Density of gas at operation condition, kg/m^3
L	Pipe length, m

Introduction

The last decade witnessed significant growth in awareness for greenhouse gas emissions, global warming and fuel scarcity. Thus, the need arises to implement a new energy carrier that would provide the same energy value and contribute to reducing CO_2 emissions. One such potential fuel is hydrogen, which is becoming increasingly popular [2,3,49]. This means that it will be produced in large quantities and will certainly need to be transported from the production location to the end-user.

Pipelines are the cheapest and safest way to transport hydrogen over long distances with minimal energy loss [22,60,88]. One of the most important barrier that interrupt hydrogen to be broadly utilized is the present lack of hydrogen infrastructure [88].

Experience indicates that implementing a new technology does not essentially require drastic change; it can be realised by small modifications to existing methods and infrastructure.

There are suggestions to inject hydrogen into the existing natural gas grid, which permits the fast and cost effective transition to hydrogen energy transport. Some authors [57] reported that the injection of hydrogen is possible and others [11,13,16,23,73,81] examined the possibility of using the existing natural gas pipeline network to transport both pure hydrogen and an admixture of natural gas-hydrogen. The

Please cite this article in press as: Messaoudani Zl, et al., Hazards, safety and knowledge gaps on hydrogen transmission via natural gas grid: A critical review, International Journal of Hydrogen Energy (2016), http://dx.doi.org/10.1016/j.ijhydene.2016.07.171