



ENVIRONMENTAL IMPACTS OF HYDROGEN PLANTS

Doc 122/18

Revision of Doc 122/11

EUROPEAN INDUSTRIAL GASES ASSOCIATION AISBL



AVENUE DES ARTS 3-5 • B – 1210 BRUSSELS
Tel: +32 2 217 70 98 • Fax: +32 2 219 85 14
E-mail: info@eiga.eu • Internet: www.eiga.eu

AVA Documents
Document Sharing Hub



ENVIRONMENTAL IMPACTS OF HYDROGEN PLANTS

Prepared by WG-5 Environment

Disclaimer

All technical publications of EIGA or under EIGA's name, including Codes of practice, Safety procedures and any other technical information contained in such publications were obtained from sources believed to be reliable and are based on technical information and experience currently available from members of EIGA and others at the date of their issuance.

While EIGA recommends reference to or use of its publications by its members, such reference to or use of EIGA's publications by its members or third parties are purely voluntary and not binding.

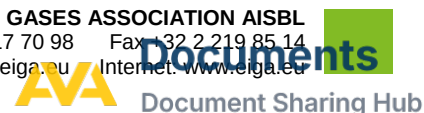
Therefore, EIGA or its members make no guarantee of the results and assume no liability or responsibility in connection with the reference to or use of information or suggestions contained in EIGA's publications.

EIGA has no control whatsoever as regards, performance or non performance, misinterpretation, proper or improper use of any information or suggestions contained in EIGA's publications by any person or entity (including EIGA members) and EIGA expressly disclaims any liability in connection thereto.

EIGA's publications are subject to periodic review and users are cautioned to obtain the latest edition.

© EIGA 2018 - EIGA grants permission to reproduce this publication provided the Association is acknowledged as the source

EUROPEAN INDUSTRIAL GASES ASSOCIATION AISBL
Avenue des Arts 3-5 B 1210 Brussels Tel +32 2 217 70 98 Fax +32 2 219 85 14
E-mail: info@eiga.eu Internet: www.eiga.eu



Document Sharing Hub

Table of Contents

1	Introduction	0
2	Scope and purpose	0
2.1	Scope.....	0
2.2	Purpose	0
3	Definitions	0
3.1	Environmental aspect	0
3.2	Environmental Impact.....	0
4	Hydrogen production.....	0
4.1	General environmental aspects and impacts and links to other EIGA documents	0
4.2	Manufacture of hydrogen and the Industrial Emissions Directive (IED).....	1
4.3	Production methods.....	1
4.3.1	Electrolysis	1
4.3.2	Chemical processes	1
4.3.3	Steam reforming	1
4.3.4	Methanol cracking	2
4.3.5	Hydrogen purification	2
4.4	Carbon dioxide emissions for the different options	2
4.5	Environmental impact of a hydrogen production plant	2
4.5.1	Principal impacts	2
4.5.2	Compression	3
4.5.3	Desulphuriser	4
4.5.4	Reformer.....	5
4.5.5	High temperature shift	5
4.5.6	PSA Adsorbents	5
4.5.7	Maintenance	5
4.5.8	Storage	7
5	References.....	7
	Appendix 1: EIGA Document Links to ISO 14001 2015	9
	Appendix 2: Schematic of Hydrogen Production Plant	11
		11
	Appendix 3: Emissions or Waste – Hydrogen and Carbon Monoxide Plant.....	12

Amendments to 122/11

Section	Change
All	Editorial changes in line with current EIGA style manual
4.5.8.4	Section on Energy Management Added

NOTE Technical changes from the previous edition are underlined

1 Introduction

This publication details the environmental impacts of the production of hydrogen and gives guidelines on how to reduce this impact.

2 Scope and purpose

2.1 Scope

The publication concentrates on the environmental impacts of hydrogen production. It does not give specific advice on health and safety issues, which shall be taken into account before undertaking any activity. On these issues the relevant EIGA documents, and or national legislation should be consulted for advice.

2.2 Purpose

This publication is intended to serve as a general guide for hydrogen plant operations to assist in putting in place a formal environmental management system that can be certified by an accredited third-party verifier. It aims to provide a guide for operating managers for identifying and reducing the environmental impacts of these operations.

It also provides the basis for establishing the Best Available Techniques for the purposes of *Directive 2010/75/EU of the European Parliament and of the Council of 24 November 2010 on industrial emissions (integrated pollution prevention and control)* [1]¹. It is not intended as a detailed design guide for hydrogen plant, but can be used to identify the possible impacts. Best Available Techniques issues are also addressed in Doc 155 *Best Available Techniques for hydrogen production by steam methane reforming* [2] and Doc 183 *Best Available Techniques for the co-production of hydrogen, carbon monoxide and their mixtures by steam reforming* [3].

Hydrogen and carbon monoxide plants with hydrogen production >25 tonnes per day (TPD) require a greenhouse gases permit under Directive 2003/87/EC of the European Parliament and of the Council of 13 October 2003 establishing a scheme for greenhouse gas emission allowance trading within the Community and amending Council Directive 96/61/EC [4].

3 Definitions

3.1 Environmental aspect

These are elements of an organisation's activities, products or services that can interact with the environment. For example, use of energy or transportation of products.

3.2 Environmental Impact

Any change to the environment, whether adverse or beneficial, wholly or partially resulting from an organization's environmental aspects. (Source: ISO 14001:2015 *Environmental Management*) [5]. For example: the contamination of water with hazardous substances

4 Hydrogen production

4.1 General environmental aspects and impacts and links to other EIGA documents

This document covers the environmental impact of hydrogen plants which are summarised in Appendix 2.

There are several other EIGA publications that provide more details on general environmental issues, legislation for the gas industry and operational good environmental practices e.g. EIGA Doc. 88, *Good environmental management practices for the industrial gas industry (GEMPs)* [6]. A list of these documents and their links to the ISO 14001 environmental management systems standard [5] is

¹ References are shown by bracketed numbers and are listed in order of appearance in the reference section

provided in Appendix 1. Appendix 1 also shows which of these documents are relevant to hydrogen plant operations.

4.2 Manufacture of hydrogen and the Industrial Emissions Directive (IED)

This directive covers hydrogen production in Annex 1 Section 4.2 (a), Production of inorganic chemicals.

Hydrogen production is also covered in Section 1.2, Refining of mineral oil and gas, for those plants using steam methane reforming, due to the fact that this process has similar emissions to a combustion process.

EIGA Doc. 155 [2] and EIGA Doc. 183 [3] provide a more detailed summary of the applicability of the Best Available Techniques required under the IED directive.

4.3 Production methods

Hydrogen is the ninth most frequent element in the crust of the earth, so it is available as a natural resource in a bound form as water or hydrocarbons. Hydrogen can be produced either by electrolysis of water, or by a chemical process.

4.3.1 Electrolysis

In the electrolysis process water is split by electrical energy to obtain hydrogen plus oxygen. In this process hydrogen is gained at the cathode with a purity of almost 100%.

Depending on size, type and conditions of the plant, the energy requirement for the production of 1 Nm³ hydrogen by means of electrolysis is in the range of 4.2 to 4.6 kW and this corresponds to a primary energy requirement of approx. 1.3 Nm³ methane per 1 Nm³ hydrogen. This figure can be reduced to 1.1 if the oxygen obtained as a by-product finds use in another process.

4.3.2 Chemical processes

Hydrocarbons are split by steam at temperatures between 250 and 900 deg C in the presence of a catalyst. A 75% by vol. hydrogen rich synthesis gas is generated, with a purity of 99.999% by vol. after purification.

4.3.3 Steam reforming

The steam reforming process of natural gas (mainly methane) converts the hydrocarbon and steam in the presence of a nickel catalyst into a hydrogen-rich synthesis gas at a temperature between 800 and 900 deg C and a typical pressure of 15 to 20 bar. This stream is finally purified to obtain 99.999% by volume hydrogen. The classical steam reforming process requires 0.48 Nm³ methane per 1 Nm³ hydrogen.

The feed is mixed with a split stream of hydrogen and then preheated in the heat exchanger prior to passing through a sulphur removal stage. The feed is then mixed with superheated steam. Whilst passing through the catalyst in the reformer tubes, the mixture of water vapour and feed is converted into a "syngas" consisting of hydrogen, carbon monoxide, carbon dioxide, water and methane. The hot syngas passes through the heat exchanger in which the main part of the sensible heat is utilised, thus adjusting the temperature of the syngas for the subsequent carbon monoxide shift process. In the cooler following the carbon monoxide shift process, the syngas is cooled to ambient temperature, water vapour is simultaneously condensed and subsequently separated.

The syngas now passes through the molecular sieve pressure swing adsorption (PSA) purification unit where the hydrogen is purified to the required purity. Tail gas produced in the PSA purification unit and stored in the tail gas buffer tank is fed with fuel to a high velocity burner that heats the reformer. The hot flue gases of the reformer pass through the waste heat boiler prior to being used to superheat feed and steam and to preheat the feed in the heat exchangers.

A steam reformer can be used for the production of hydrogen, carbon monoxide or both, depending on its design. The emissions from the plant can differ and depend on the design, operating