

European Hydrogen Safety Panel (EHSP)
Webinar "Safety planning and management in EU hydrogen and
fuel cell projects", 22 April 2022

EUROPEAN HYDROGEN SAFETY PANEL (EHSP)

Iñaki Azkarate, PhD
European Hydrogen Safety Panel (EHSP)



A brief timeline

-  In 2006 and 2009 NoE HySafe was suggesting an activity for **sharing lessons learned and hydrogen safety experience across project boundaries** and to **this expertise eventually even beyond program terms.**
-  In 2014 the International Association for Hydrogen Safety HySafe proposed the installation of a safety panel to the Executive Director and Governing Board of the FCH JU.
-  After several discussions about formal aspects, terms of reference, vision, mission, mandates, etc. the **European Hydrogen Safety Panel was launched by the FCH 2 JU in 2017**



Kick-off meeting 2018

The Panel. Current Members

Group of experts in Hydrogen Safety constituted by 15 members



Iñaki Azkarate



Stuart Hawksworth



Thomas Jordan



Georg Wilfried Mair



Marta Maroño



Daniele Melideo



Vladimir Molkov



Ernst-Arndt Reinecke



Pratap Sathiah



Ulrich Schmidtchen



Etienne Studer



Trygve Skjold



Tom Van Esbroeck



Elena Vyazmina






Jennifer Wen



KNOWLEDGE HUB

EHSP Role

to **provide** the Clean Hydrogen JU

-  **independent safety expertise**
-  **objective information**
-  **education and training**

in different forms for various groups of stakeholders
and support the upscaling of hydrogen energy

Mission, Objectives and Activities

The EHSP assists the Clean Hydrogen JU both at programme and at project level in



assuring that hydrogen safety is adequately managed, and



promoting and disseminating hydrogen safety culture

Activities

Activities are grouped in 4 pillars and organised in Task Forces (TF)

 TF1 Support at Project level



Elena Vyazmina

 TF2 Support at Programme level



Thomas Jordan

 TF3 Data collection and assessment



Jennifer Wen

 TF4 Public Outreach



Trygve Skjold

SAFETY PLANNING AND MANAGEMENT IN HYDROGEN AND FUEL CELLS PROJECTS - GUIDANCE DOCUMENT



FUEL CELLS AND HYDROGEN 2 JOINT UNDERTAKING
(FCH 2 JU)

SAFETY PLANNING AND MANAGEMENT IN EU HYDROGEN
AND FUEL CELLS PROJECTS - GUIDANCE DOCUMENT

21 September 2021

NOTICE

This document is prepared by the European Hydrogen Safety Panel (EHSP) with the mandate and support of the Fuel Cell and Hydrogen 2 Joint Undertaking (FCH 2 JU). Neither the FCH 2 JU nor the EHSP makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favouring by the FCH 2 JU or the EHSP.

The views and opinions of authors expressed herein do not necessarily state or reflect those of the FCH 2 JU or the EHSP. Additionally, the document does not provide any approval or endorsement by the FCH 2 JU or the EHSP of any system(s), material(s), equipment or infrastructure discussed in the document.

TABLE OF CONTENTS

- 1 INTRODUCTION 1**
- 2 CONTENT OF SAFETY PLAN 2**
 - 2.1 Objectives 2
 - 2.2 An exemplary table of content of a safety plan 3
- 3 PREPARATION OF SAFETY PLAN 4**
 - 3.1 Project brief 4
 - 3.1.1 Description of a system, process or infrastructure to be developed by the project 4
 - 3.1.2 Description of safety systems and their functions 5
 - 3.1.3 Safety expertise and responsibilities in the project 5
 - 3.1.4 Relevant RCS 5
 - 3.1.5 Best safety practices 6
 - 3.1.6 Schedule of the safety plan update and reporting 6
 - 3.1.7 Composition, responsibilities and reporting schedule of a safety team 6
 - 3.2 Description of technical hydrogen safety activities 7
 - 3.2.1 Identification of safety vulnerabilities, hazards and associated risks 7
 - 3.2.2 The state-of-the-art 7
 - 3.2.3 Selection of incident scenarios 7
 - 3.2.4 Content and methods of hydrogen safety engineering to be applied 7
 - 3.2.5 Prevention and mitigation strategies and innovative engineering solutions 7
 - 3.2.6 Reporting results on hydrogen safety engineering progress and risk assessment as applicable 7
 - 3.3 Description of organisational safety activities 8
 - 3.3.1 Description of work to be performed by staff that needs formal safety procedures 8
 - 3.3.2 General safety considerations to prevent harm to people in a workplace 9
 - 3.3.3 Personnel training and education plan 9
 - 3.3.4 Safety review procedures and/or self-audits 9
 - 3.3.5 Emergency response arrangements 10
 - 3.3.6 Management of Change (MOC) procedures 11
 - 3.3.7 Reporting on safety management and lessons learnt 11
 - 3.4 Other relevant documentation, safety procedures and outreach activities 12
 - 3.4.1 Positive data reporting 12
 - 3.4.2 Crisis management procedures 13
 - 3.4.3 Dissemination plan of project findings in hydrogen safety, including closed knowledge gaps and addressed technological bottlenecks 13
- 4 SAFETY PLAN IMPLEMENTATION, MONITORING AND REPORTING 13**
 - 4.1 Performing safety reviews 13
 - 4.2 Implementation of hydrogen safety engineering process 14
 - 4.3 Examples of best practices in hydrogen safety engineering 17

- 4.4 Project safety documentation 21
- 5 EUROPEAN HYDROGEN SAFETY PANEL 21**
 - Appendix 1. Hydrogen safety terminology and abbreviations 23
 - Appendix 2. Applicable Regulations, Codes and Standards 28
 - Legal framework 28
 - Regulations and standards 28
 - Role and distinction 28
 - EU legislation 29
 - Hydrogen gas regulations 29
 - EU directives relevant for hydrogen 30
 - Hydrogen standards related to hydrogen 33
 - Appendix 3. Known best practices to implement safety strategies 36
 - Appendix 4. Methods for identification of safety vulnerabilities, hazards and risk assessment 38
 - Hazard and Operability Analysis (HAZOP) 41
 - Risk Binning Matrix 42
 - Failure Mode and Effect Analysis (FMEA) 44
 - Appendix 5. Safety plan checklist 46
 - Appendix 6. Example of a safety plan 48

Safety of Electrolysis

2020



EHSP
European Hydrogen Safety Panel
Workshop on Safety of Electrolysis
18 November 2020

FCH JU Workshop on Safety of Electrolysis
AGENDA

Welcome Remarks	FCH JU
European Hydrogen Safety Panel (EHSP)	EHSP
Session 1: Safety-related events and lessons learnt	
Hydrogen Incidents and Accidents Database (HIAD 2.0) Findings, lessons learnt, recommendations	DO JRC - EC
Case Studies - Ilford and Gangneung in South Korea History, lessons learnt	EHSP
Q&A / Panel discussion - Moderated by the EHSP	
Session 2: Hazards identification for electrolysis	
Set of prototypical hazards, Risk Evaluation and Acceptance Criteria - Overview	EHSP
HYBALANCE project hazards identification approach 1.2 MW, PEMEL, Grid services/transport/industry (DK)	AIR LIQUIDE
GRINHY2.0 project hazards identification approach 700+ kW, SOEL, Steel industry, (DE)	SUNFIRE
H2ME2 project hazards identification approach PEMEL, Hydrogen refuelling station(s)	ITM POWER
PRETZEL project hazards identification approach 25 kW, PEMEL, 100bar Outlet Pressure	WHS / IGAS ENERGY
Q&A / Panel discussion - Moderated by the EHSP	
Session 3: Safety-related framework in electrolysis	
16:10-16:20 Safety in Regulations, Codes and Standards relevant to electrolysis - Overview	RCS SCG
16:20-16:30 DJEWELS project safety approach 20 MW, AEL, Methanol production plant (NL)	NOURYON
16:30-16:40 REFHYNE project safety approach 10 MW, PEMEL, Refinery (DE)	ITM / SHELL
16:40-16:50 H2FUTURE project safety approach 6 MW, PEMEL, Steel manufacturing plant (AT)	SIEMENS / VOESTALPINE
16:50-17:00 DEMO4GRID project safety approach 4 MW, Pressurized AEL, Industrial bakery (AT)	MPREIS WARENVERTRIEBS
17:00-17:10 MULTIPLY project safety approach 2.6 MW, SOEL, Biodiesel refinery (NL)	SUNFIRE
17:10-17:30 Q&A / Panel discussion - Moderated by the EHSP	
17:30 Closing Remarks	FCH 2 JU / EHP

Safe Storage of Hydrogen

2021



European Hydrogen Safety Panel
Workshop "Safe Storage of Hydrogen"
18 November 2021

Workshop on Compressed Gas Hydrogen in road transport infrastructure

	FCH 2 JU
	FCH 2 JU
	EHSP
Workshop on hydrogen storage	
Standards	JRC
Events involving	EHSP
	EHSP
Workshop on (CGH2) - On-board storage	
Discussions	EHSP
	BMW
	CLEAN ENERGY PARTNERSHIP
	VDL
10:30-10:40 H2HAUL project - Heavy-duty vehicles	
10:40-10:50 REVIVE project - Heavy-duty vehicles	ALL ENGINEERING
10:50-11:00 THOR project - CGH2 Tanks	FAURECIA
11:00-11:10 HYTUNNEL-CS project - Safe design of TPRD/ TPRD-free tanks	UNIVERSITY OF ULSTER
11:10-11:40 Q&A / Panel discussion	EHSP
11:40-11:45 Break / contingency time	

Outcomes: Assessment and lessons learnt from HIAD 2.0



FUEL CELLS AND HYDROGEN 2 JOINT UNDERTAKING (FCH 2 JU)

Statistics, lessons learnt and recommendations from the analysis of the Hydrogen Incidents and Accidents Database (HIAD 2.0)

21 September 2021

NOTICE

This document is prepared by the European Hydrogen Safety Panel (EHSP) with the mandate and support of the Fuel Cell and Hydrogen Joint Undertaking (FCH 2 JU). Neither the FCH 2 JU nor the EHSP makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favouring by the FCH 2 JU or the EHSP.

The views and opinions of authors expressed herein do not necessarily state or reflect those of the FCH 2 JU or the EHSP. Additionally, the document does not provide any approval or endorsement by the FCH 2 JU or the EHSP of any system(s), material(s), equipment or infrastructure discussed in the document.

TABLE OF CONTENTS

- 1. INTRODUCTION 1
- 2. DATA COLLECTION, ANALYSIS AND REPORTING 2
- 3. OVERVIEW OF THE EVENTS 3
- 4. STATISTICS 4
- 5. LESSONS LEARNT 5
 - 5.1 Lessons learnt related to system design 5
 - 5.2 Lessons learnt related to system manufacturing, installation and modification 21
 - 5.3 Lessons learnt related to operator errors 23
 - 5.3.1 Lessons learnt related to job factors 23
 - 5.3.2 Lessons learnt related to individual/human factors 25
 - 5.3.3 Lessons learnt related to organization and management factors 26
 - 5.4 Lessons learnt for the first responders 27
 - 5.5 Highlighted incidents with good lessons to be learnt related to cascade failure 28
- 6. RECOMMENDATIONS 6
 - 6.1 Recommendations for different operational modes 6
 - 6.2 Recommendations for different industry sectors 6
 - 6.2.1 Hydrogen energy applications 6
 - 6.2.2 Other industrial sectors 6
 - 6.3 Other sectors 6
 - 6.4 Recommendations concerning human errors 6
- 7. CONCLUDING REMARKS 7



Figure 1: Flow chart of the process from data collection to final publishing and dissemination.

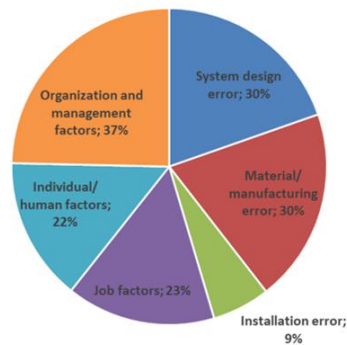


Figure 9: Causes of hydrogen incidents (multiple causes per event considered).

Table 1: HIAD 2.0 events classified by consequence and operation mode

Total number events	Number events by consequence			
	Explosions	Jet fires	Unignited hydrogen release	No hydrogen release
424	238	117	55	14
Number events by operational mode				
	Normal operation	Outside normal operation	Unclear	
	299	113	12	

Table 2: HIAD 2.0 events classified by industry sector

Sector	Number of events by sector
Chemical/ Petrochemical industry	259
Hydrogen transport and distribution	43
Nuclear power plant	23
Laboratory / R&D	15
Power generation	13
Hydrogen production	10
Aerospace	5
Entertainment	3
Hydrogen-powered vehicle	2
Stationary fuel cell	0
Other/Unknown	
Other	34
Total	461

Finally, Table 3 lists the number of events according to causes. It should be noted that some events had multiple causes.

Table 3: HIAD 2.0 events classified by causes

Cause	Number of events by causes
System design error	126
Material/ manufacturing error	127
Installation error	38
Job factors	98
Individual/ human factors	94
Organization and management factors	158

“Statistics, lessons learned and recommendations from analysis of HIAD 2.0 database” will appear soon in International Journal of Hydrogen Energy

Outcomes: Support at Programme Level

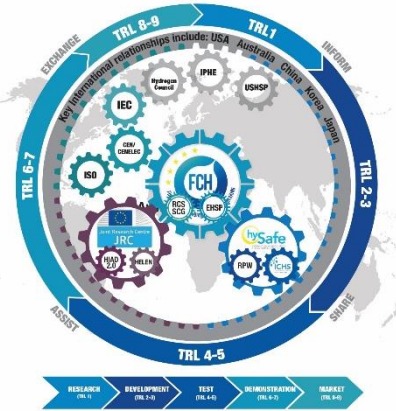
Emergency Crisis Management



Task 2 – Strategic Support

Emergency Crisis Management

Stuart Hawksworth



Collaboration: EHSP-USHSP



Hydrogen Safety Forum

Stuart Hawksworth & Chris LaFleur

Representing

European Hydrogen Safety Panel & United States Hydrogen Safety Panel

22 June 2021



ICHS



hySafe The Scottish Government and IA HySafe invite you to the unique

9th INTERNATIONAL CONFERENCE ON HYDROGEN SAFETY 2021

Safe Hydrogen for Net Zero
Edinburgh, 21-24 September 2021

ICHS 2021

hySafe INTERNATIONAL ASSOCIATION FOR HYDROGEN SAFETY

Scottish Government Rialtas na h-Alba gov.scot

Registration Open
<https://hysafe.info/ichs2021/>

Outcomes: Public Outreach

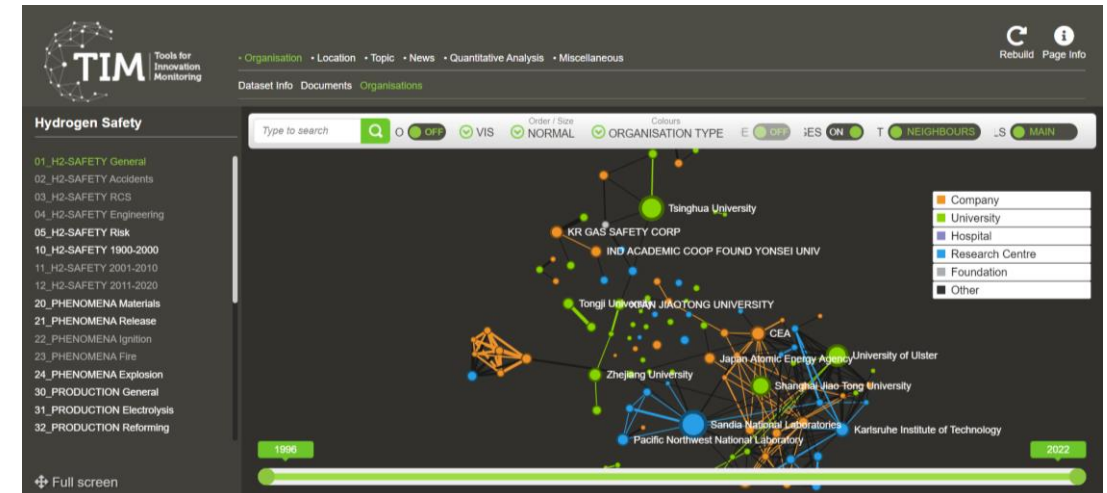
Communication Strategy // Website // FAQs // TIM // KEY MESSAGES

Key Messages

- Hydrogen will play an essential role in energy systems as a clean and sustainable energy carrier.
- To bring the benefits of hydrogen to society, hydrogen technologies must be safely developed and used across a variety of applications and sectors.
- Hydrogen systems can be as safe as systems based on conventional energy carriers, provided the specific properties of hydrogen and the hydrogen system are properly addressed.
- Hydrogen safety is an active area of research that supports the implementation and operation of hydrogen systems.
- The EHSP provides impartial expertise and objective information to relevant stakeholders, including the public.
- The EHSP supports stakeholders on issues related to hydrogen safety, including general advice, safety reviews, and accident investigations.
- The EHSP supports and promotes the development of strong safety cultures in organisations engaged in hydrogen technologies.



https://www.timanalytics.eu/TimTechPublic/main.jsp?dataset=s_1622



Thank you



Get in contact with the EHSP by email at
EHSP@clean-hydrogen.europa.eu

