SINTEF

SH_2IFT-2: Safe Hydrogen Fuel Handling and Use for Efficient Implementation 2

Thor Anders Aarhaug, SH_2IFT Workshop May 4 2022

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Photo: RISE Fire Research

Background

Hydrogen is an important vector in the ongoing transition to renewable energy sources. Insufficient knowledge about critical safety aspects related to large scale rollout of hydrogen technologies constitutes a considerable bottleneck for industry, government, end users and the general public.

Goals

SH2IFT-2 aims to close critical knowledge gaps identified by stakeholders from industry and government through development and redevelopment of existing modelling tools, leak-, fire- and explosion experiments of various scale, but also research based input to guidelines for safe use of hydrogen.

SH2IFT-2 will explore a risk-based approach for operational safety. The strength of knowledge of risk evaluations for hydrogen systems will be investigated through studies of selected systems. The project aims to make the risk evaluations meaningful and available for decision makers and other stakeholders

Title: Safe Hydrogen Fuel Handling and Use for Efficient Implementation 2

Project manager: SINTEF AS v/ Thor Anders Aarhaug

Partners: SINTEF, RISE, NTNU, UiS, UiB, USN, NORCE, GEXCON, EQUINOR, GASSCO, TOTAL, SAFETEC, Trelleborg Offshore, Møre og Romsdal Fylkeskommune, Greenstat Hydrogen, Ballard Power Systems, Air Liquide, AkzoNobel, ENGIE, Shell Global Solutions, BKK, Technip, GASNOR, GRTGAZ, BP, Karlsruhe Institute of Technology, Demokritos

Duration: 2021 - 2025

Type: Kompetansebyggende prosjekt for næringslivet (KSP)

Budget: 14,0 MNOK from NFR (50 %)

NFR Project Number: 327009

Consortium

Sponsors:

- EQUINOR
- GASSCO
- TOTAL
- SAFETEC
- Trelleborg Offshore
- Møre og Romsdal Fylkeskommune
- Greenstat Hydrogen
- Ballard Power Systems
- Air Liquide
- AkzoNobel
- ENGIE
- Shell Global Solutions
- BKK
- Technip
- GASNOR
- GRTGAZ
- BP

Project main objectives

- The overall objective of SH2IFT-2 is to
  - develop new knowledge on critical aspects of hydrogen safety
  - facilitate the competence building required for supporting widespread use of hydrogen in society

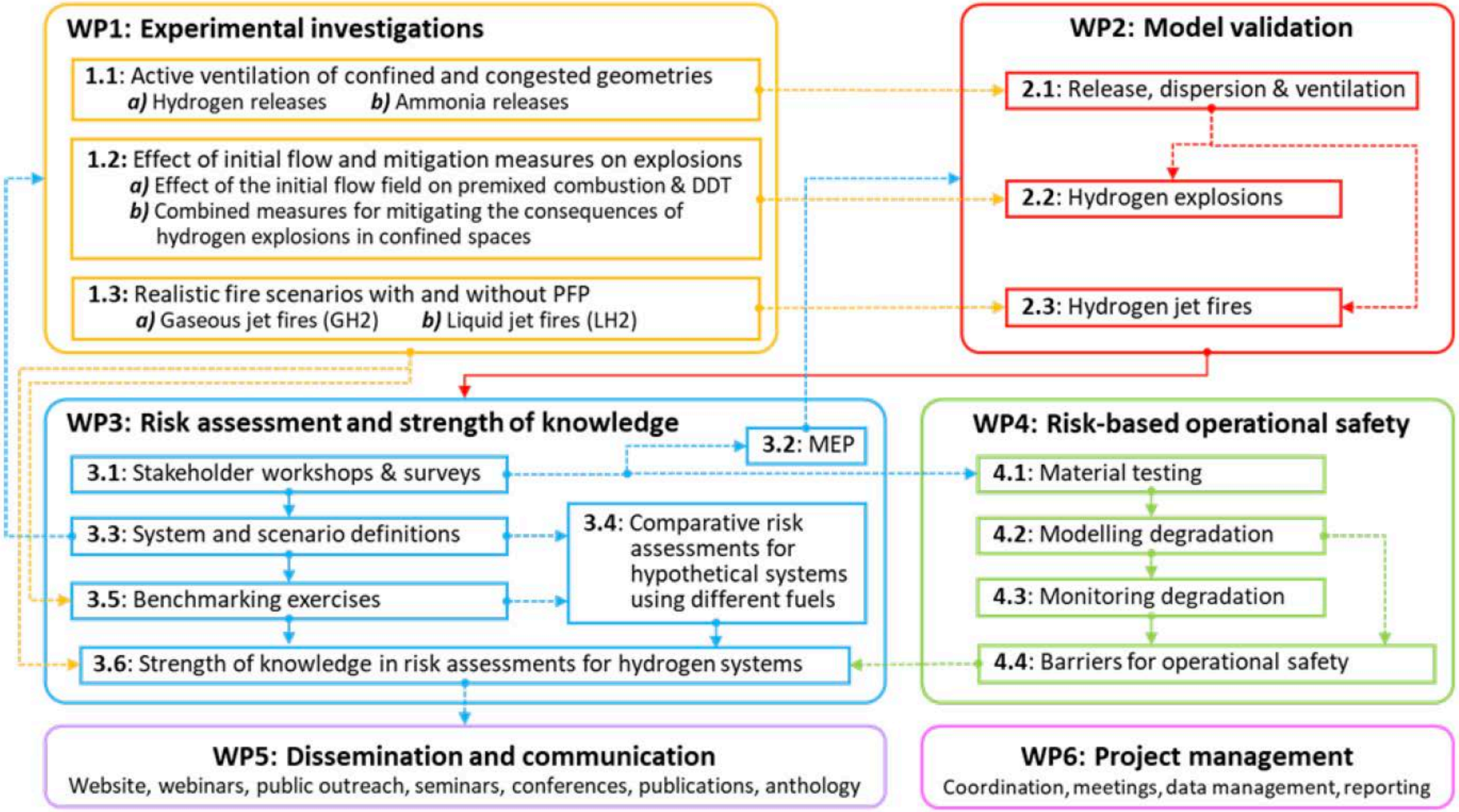
- The project will work to improve solutions for safe handling of hydrogen and hydrogen-based energy carriers by
  - developing new, and improve existing, modelling tools
  - perform large-scale release, fire and explosion experiments
  - provide input to guidelines for safe use of hydrogen

- SH2IFT-2 aims to close critical knowledge gaps identified by stakeholders from industry and government through
  - development and redevelopment of existing modelling tools, leak-, fire- and explosion experiments of various scale
  - research based input to guidelines for safe use of hydrogen

Work packages

- WP1 Experimental investigations (**RISE**)
- WP2 Model validation (**GEXCON**)
- WP3 Risk assessment and strength of knowledge (**UiB**)
- WP4 Risk-based operational safety (**NTNU**)
- WP5 Dissemination and communication (**SINTEF**)
- WP6 Project management (**SINTEF**)

Project structure

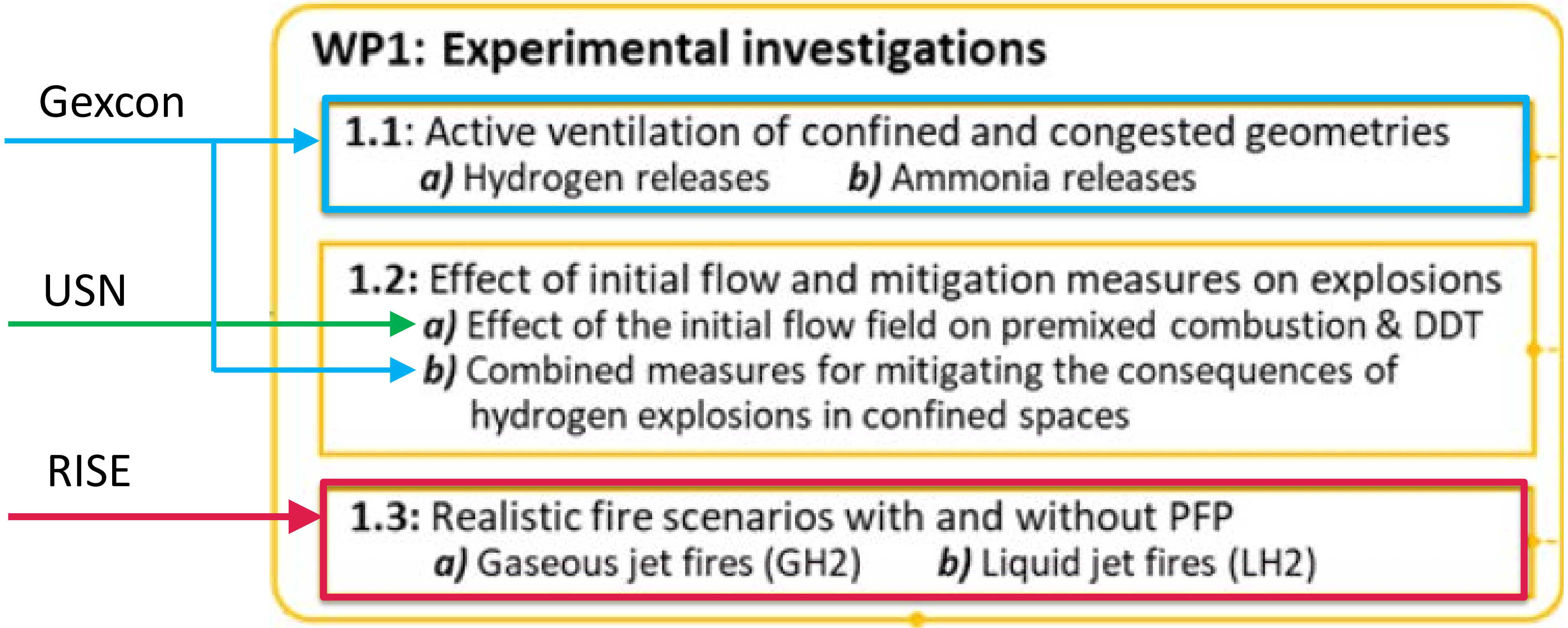


Tasks, deliverables milestones

		Year 1				Year 2				Year 3				Year 4			
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
WP1	**Experimental investigations**																
T1.1a	Active ventilation - hydrogen releases											↓					
T1.1b	Active ventilation - ammonia releases											D1.1					
T1.2a	Effect of inital flow field on combustion, DDT													D1.2			
T1.2b	Combined mitigation measures																
T1.3a	Realistic fire scenarios: GH2										D1.3						
T1.3b	Realistic fire scenarios: LH2														D1.4		
WP2	**Model validation**																
T2.1	Release, dispersion & ventilation															↓	
T2.2	Hydrogen explosions															↓	
T2.3	Hydrogen jet fires															D2.1	
WP3	**Risk assessment and strength of knowledge**																
T3.1	Stakeholder workshops & surveys	↓				↓				↓				↓			↓
T3.2	Method Evaluation Protocol (MEP)	D3.1															
T3.3	System and scenario definitions			D3.2													
T3.4	Comparative risk assessments			D3.3		↓				↓				↓			↓
T3.5	Benchmarking exercises					↓				↓				↓			↓
T3.6	Strength of knowledge in risk assessments for hydrogen systems					D3.4				D3.5				D3.6			D3.7
WP4	**Risk -based operational safety**																
T4.1	Material testing							D4.1									
T4.2	Modelling degradation mechanisms													D4.2			
T4.3	Monitoring degradation mechanisms														↓		
T4.4	Barriers for operational safety														D4.3		
WP5	**Dissemination and communication**																
T5.1	Website, webinars, public outreach		D5.1														
T5.2	Workshops, webinars, conferences																
T5.3	Publications and anthology																D5.2
WP6	**Project management**																
T6.1	Data management plan		D6.1														
T6.2	Project management, reporting		MS1						MS2								

Figure 3: *Gantt chart with WPs, indicating timing of milestones (M) and deliverables*

WP1: experimental



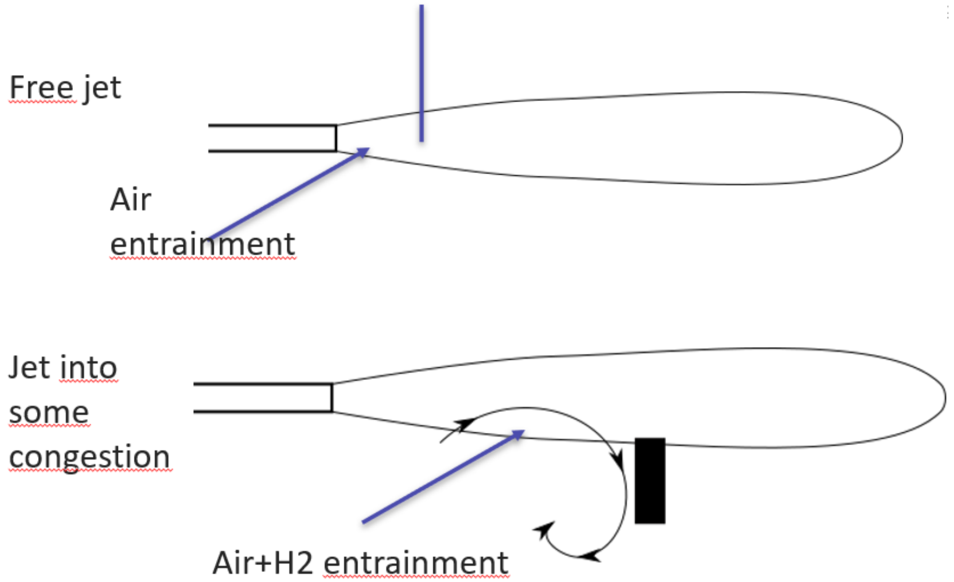
Task 1.1 Active ventilation of confined and congested geometries ($H_2 + NH_3$)

- **Objective**: To investigate measures to prevent the formation of explosive and toxic atmospheres from accidental releases of hydrogen and ammonia, in enclosed spaces using active ventilation as the primary means of protection
- Larger release rate experiments required to investigate the limitations of active ventilation systems
- Establish database for experiments for validation of models for design of ventilation systems taking into account geometry, internal congestion, ...

Task 1.2 Effect of initial flow field on explosions

- Experiments with and without mitigation measures
- Vary air-entrainment with geometry
- Laboratory scale experiments
- Larger scale experiments
- Simulations
- Can DDT in mixing layer be obtainted?

Measurements:
-Conc (unignited)
-Pressure (ignited)
-High speed camera
-Particle image velocimetry



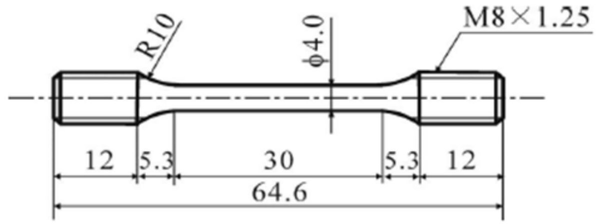
T1.3 Realistic fire scenarios

Objectives

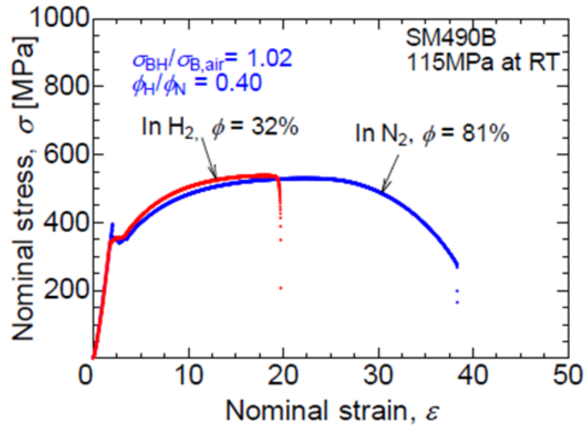
- Evaluating the impact of hydrogen jet fires and cryogenic releases on pressurized equipment for realistic release scenarios

- Evaluating the performance of Passive Fire Protection (PFP) for safeguarding pressurized equipment against hydrogen jet fires and cryogenic releases

Task 4.1 Material safety



Tensile specimen



Stress-strain curve

__Main objective__: individuation and quantification of the parameters affecting hydrogen degradation toward the quantification of the Damage Factor (DF) necessary for the definition of the Frequency of Failure

Material system: ferritic steel used for pipelines envisioned as viable solution for high volume hydrogen gas transport → X65 base metals (and welds)

Testing Type: Slow strain rate tensile testing in high purity pressurized gaseous hydrogen

Parameters studied:

- Hydrogen gas pressure (P_{H2}) (in the range from 50 bar to 500 bar)
- Temperature (range between 0 ℃ and 200 ℃)
- Input from Survey (T3.1)

Planning of experimental activities

- Workshop held March 23. for the consortium on defining experimental program
  - 3.1 Stakeholder workshop and surveys -> WP1
  - 3.3 System scenario definitions
- Survey on comparative risk assessment in preparation
  - Input to definition of systems
  - Input to risk assessment process
  - Will provide definition for systems that will be used in benchmark studies for comparative risk asessments

- More information on project web: http://sh2ift-2.com

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