Clean Hydrogen Partnership

European Hydrogen Safety Panel (EHSP)

Statistics, lessons learnt and recommendations from the analysis of HIAD 2.0 database

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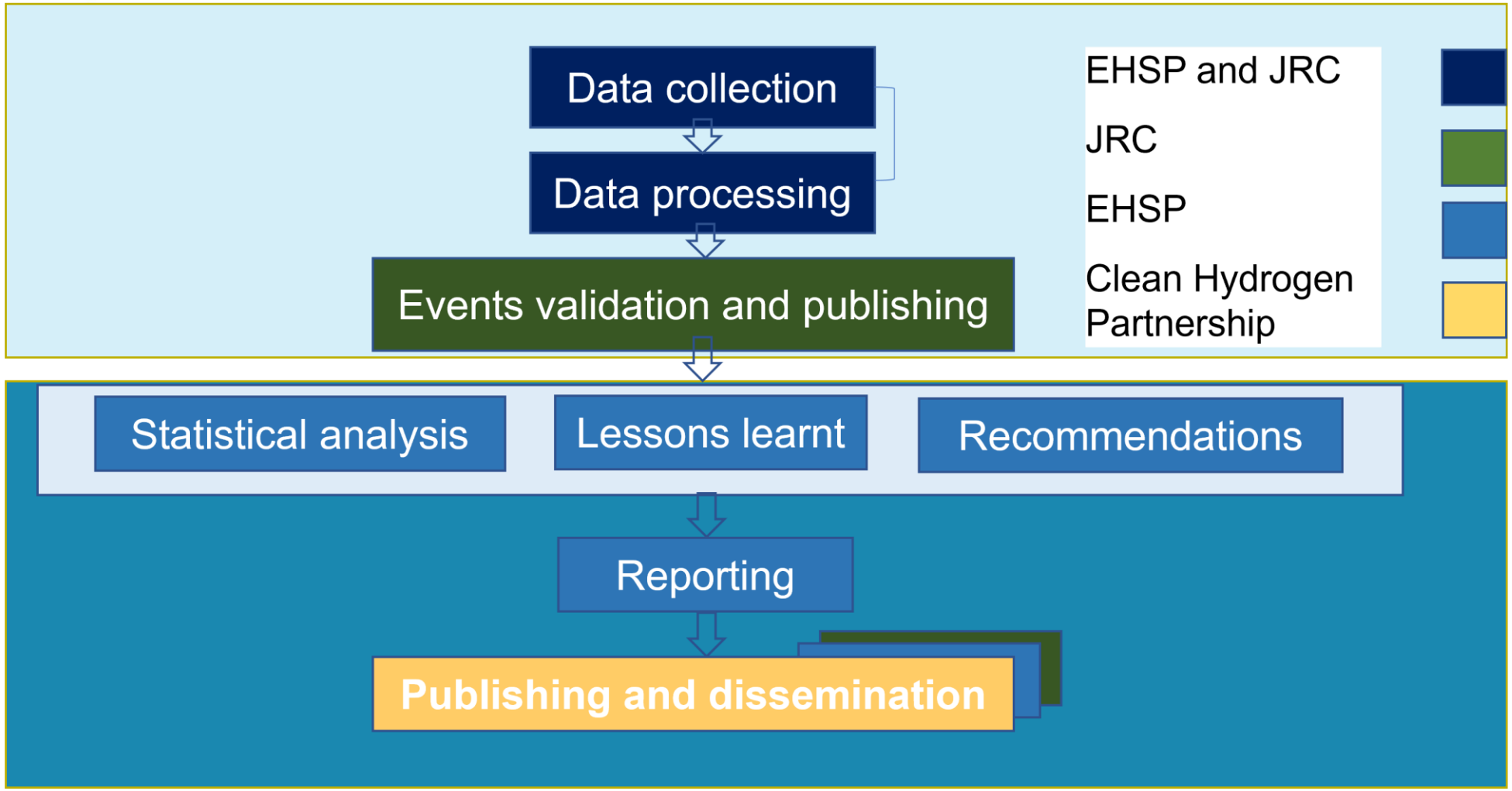
Introduction

- This presentation follows that of Pietro Moretto (JRC) about HIAD
- It will also refers to the following document covered in the presentation by

  Dr. Elena Vyazmina

  Chapter 3 of "Safety planning and management in EU hydrogen and fuel cells projects - guidance document", EHSP, 21 September 2021.
  https://www.fch.europa.eu/page/european-hydrogen-safety-panel

Overview of the data collection and assessment process



The methodology

- **Severity:** European scale of industrial accidents

  https://www.aria.developpement-durable.gouv.fr/wp- content/uploads/2014/08/European-scale-of-incidents.pdf)
  - Quantities of hydrogen involved (Seveso threshold or the amount of hydrogen involved)
  - Human consequences (fatalities, injured with hospitalisation, slightly injured)
  - Economic consequences (property damage or economic cost)

- **Nature:** Explosion, fire, unignited release, near miss

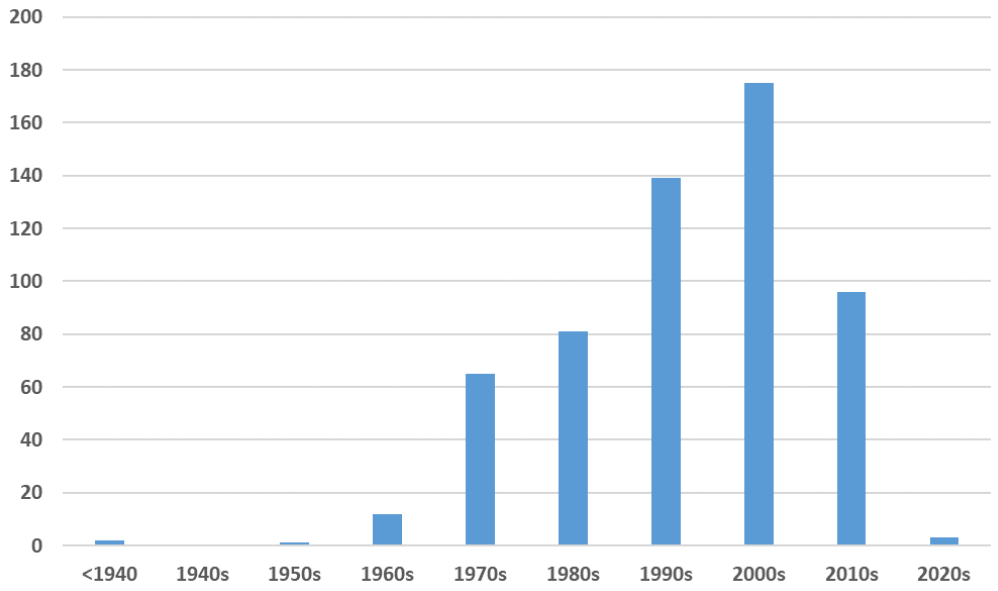
- **Two groups of cause categories**
  - System design, material, manufacturing, and installation
  - Job factors, individual/human factors, and safety management system factors

- **Recommendations** (based on EHSP safety principles *https://www.fch.europa.eu/sites/default/files/Safety_Planning_for_Hydrogen_and_Fuel_Cell_Projects_Release1p31_20190705.pdf*)

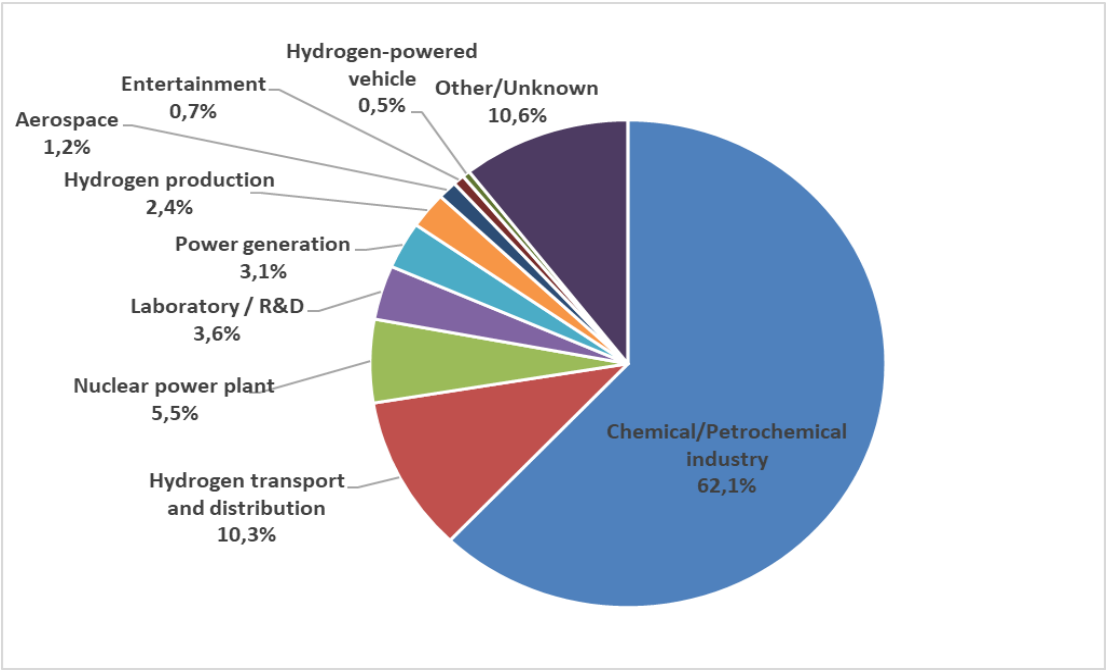
Results from the statistics analysis (1)

The analysis reported here is based on the 706 incidents, which were in the database as of May 2021.

Years



Industrial sectors



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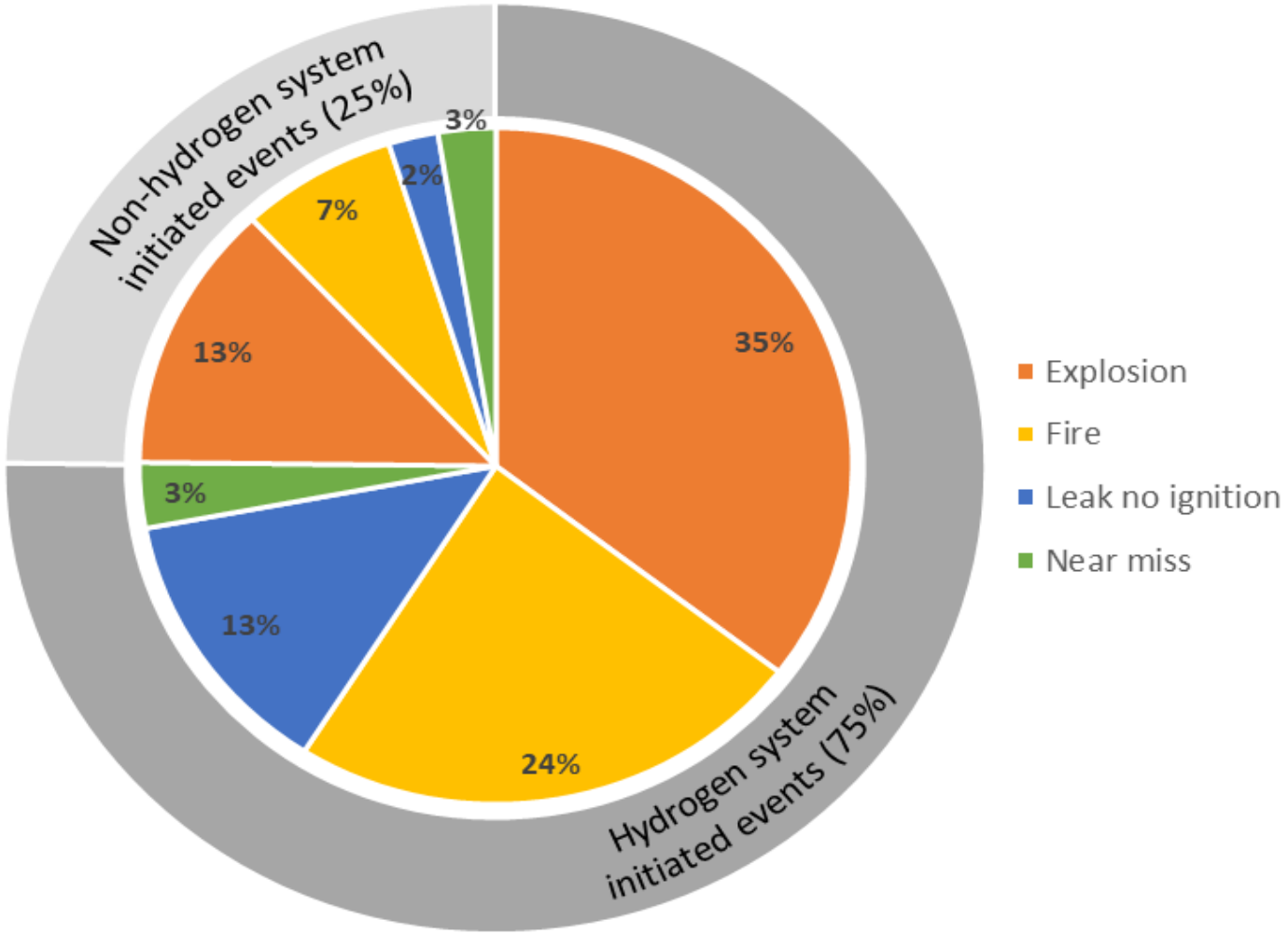
Results from the statistics analysis (2)



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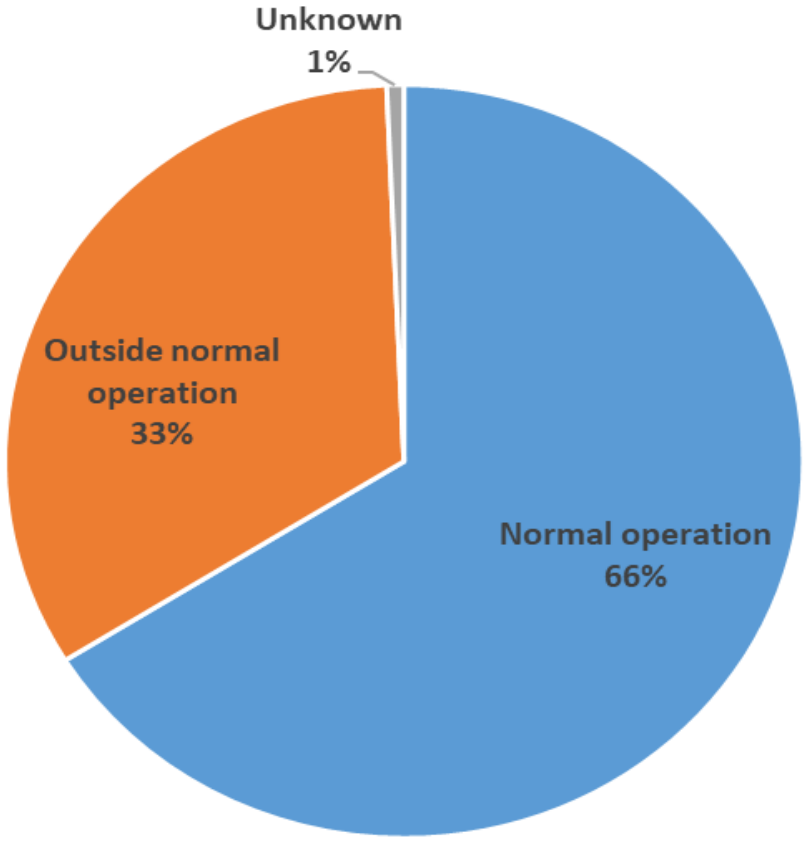
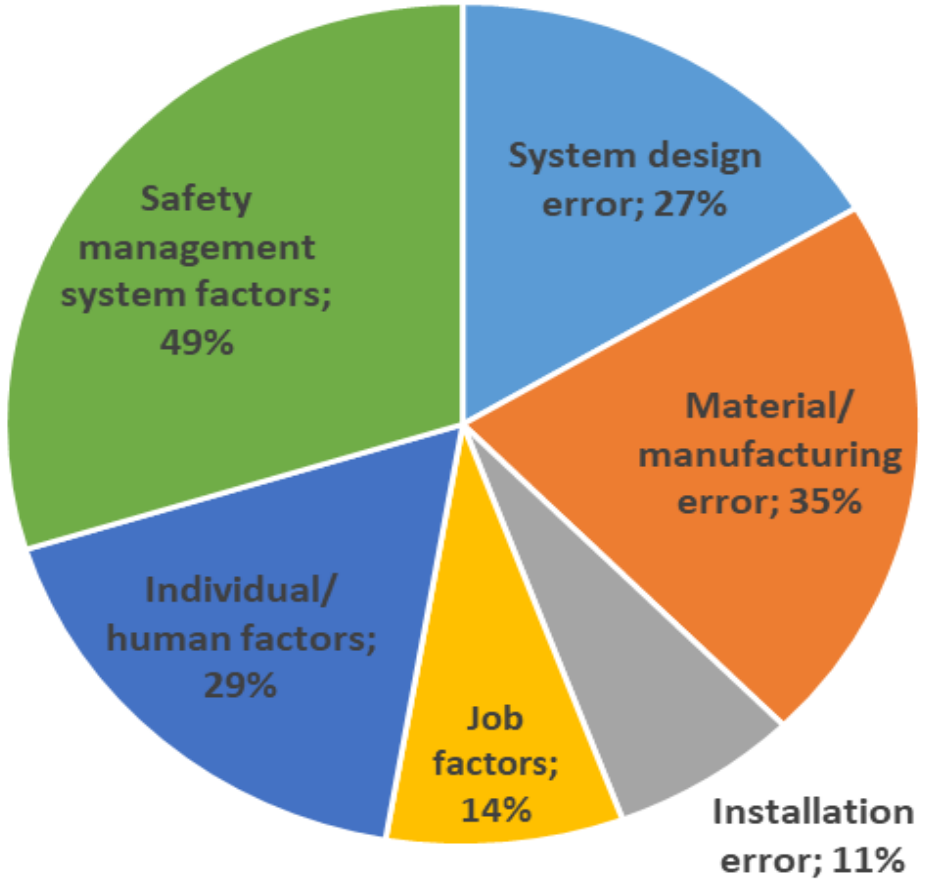
Results from the statistics analysis (3)

Operational mode



Causes (multiple entries per incident possible)



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Lessons learnt

The lessons learned are grouped into the following four main categories:

- System design
- System manufacturing, installation, and modification
- Human factors
- Emergency response

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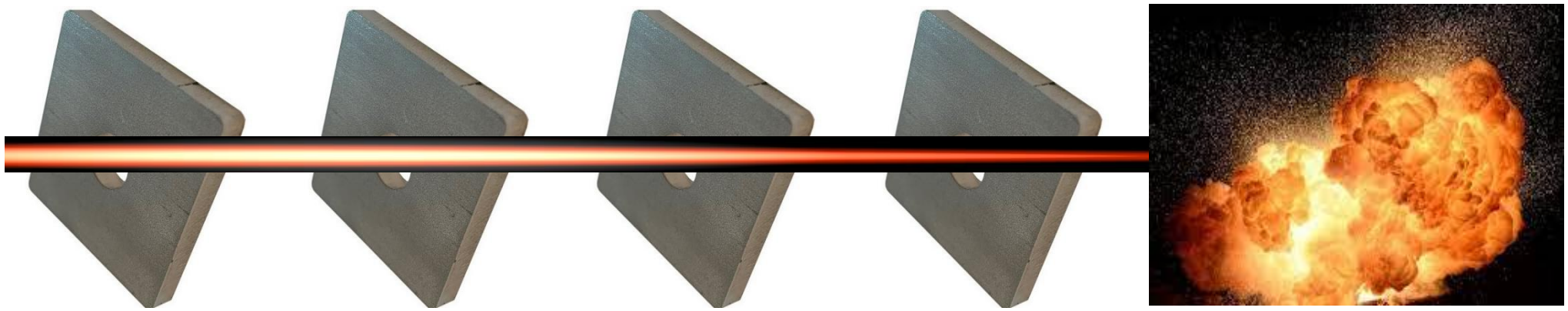
Lessons learnt in relation to cascading effects

James Reason's Swiss Cheese theory *https://en.wikipedia.org/wiki/Swiss_cheese_model*

Cascading effects of minor events could result in extremely serious consequences



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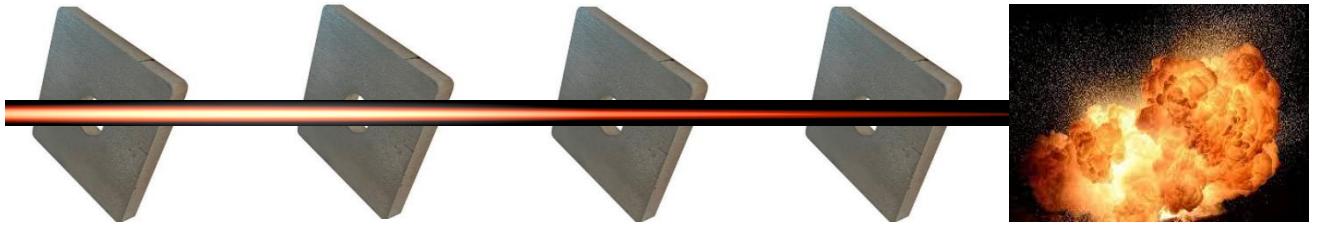
Example (Event ID477) of cascading effects

- Prosecutor's report on Gangeung Hydrogen Tank Explosion Accident, May 2019, South Korea
- The following text is adapted from the English translation by INERIS about the contributing factors:
  - Oxygen removing component omitted in the system …
  - Buffer tank static spark remover was omitted during construction…
  - Operator made fault by running water electrolysis system lower than operation power level, which induced increase of O_2 concentration…
  - The O_2 concentration was detected as > 3%, which required O_2 detector and remover. However, the operator ignored this issue and continued operation to reach 1000 hours of required experiment validation time.
  - Safety management team did not follow safety regulation to daily test hydrogen quality.



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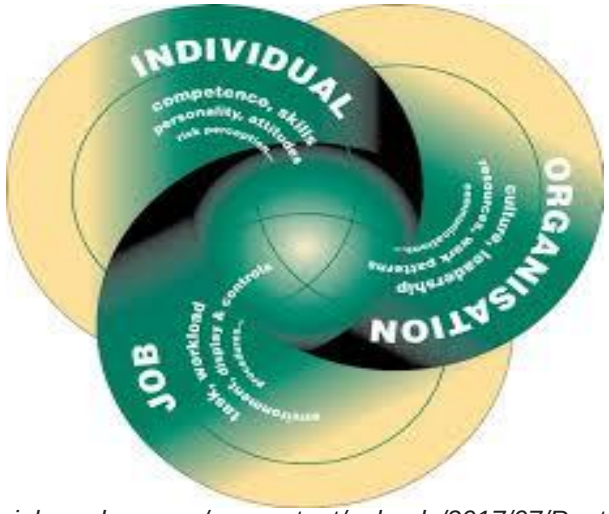
Lessons learnt related to human factor

- Lack of regular maintenance or inspection, special attention for safety devices during maintenance
- Reoperation after repair
- Individual/human factors, lack of clear instructions
- Reusing tanks or pipes previously containing flammable liquid or gas without thorough purging



https://www.ciobacademy.org/wp-content/uploads/2017/07/Root-Cause-Analysis-2018.pdf

Definition of Health and Safety Executive (HSE)

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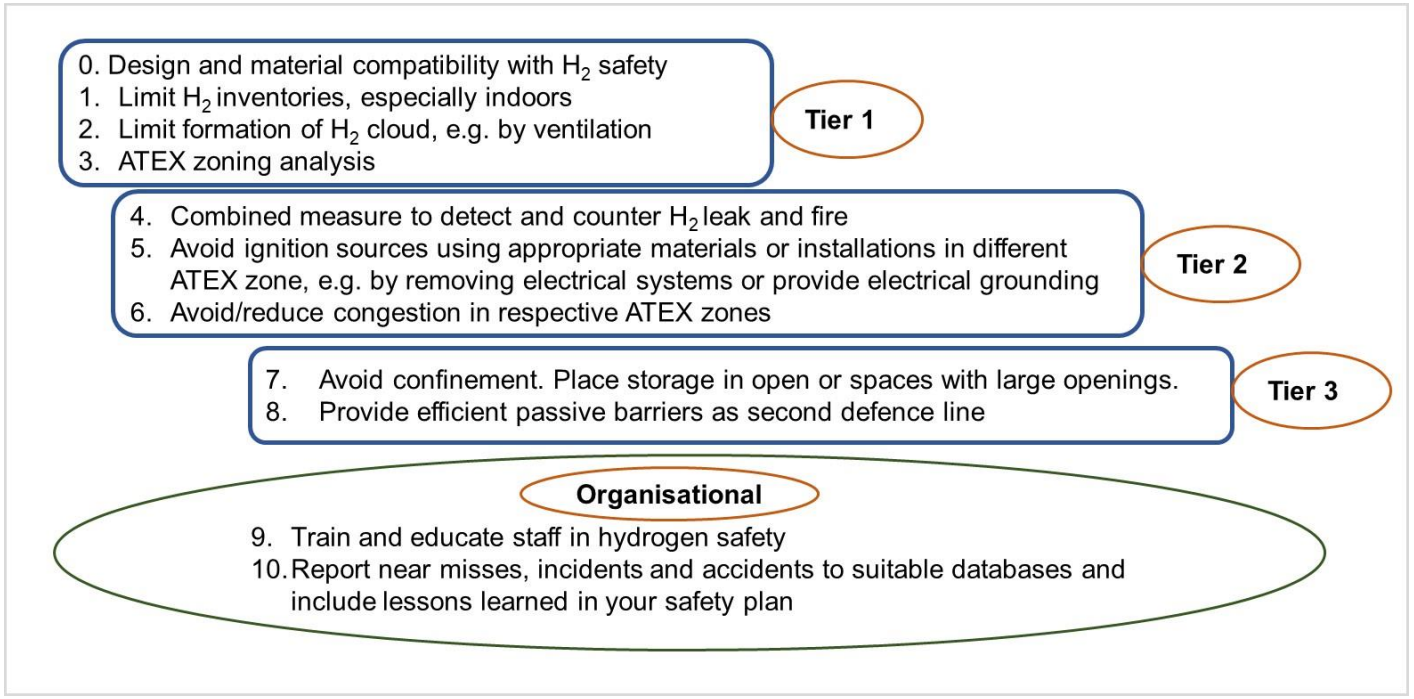
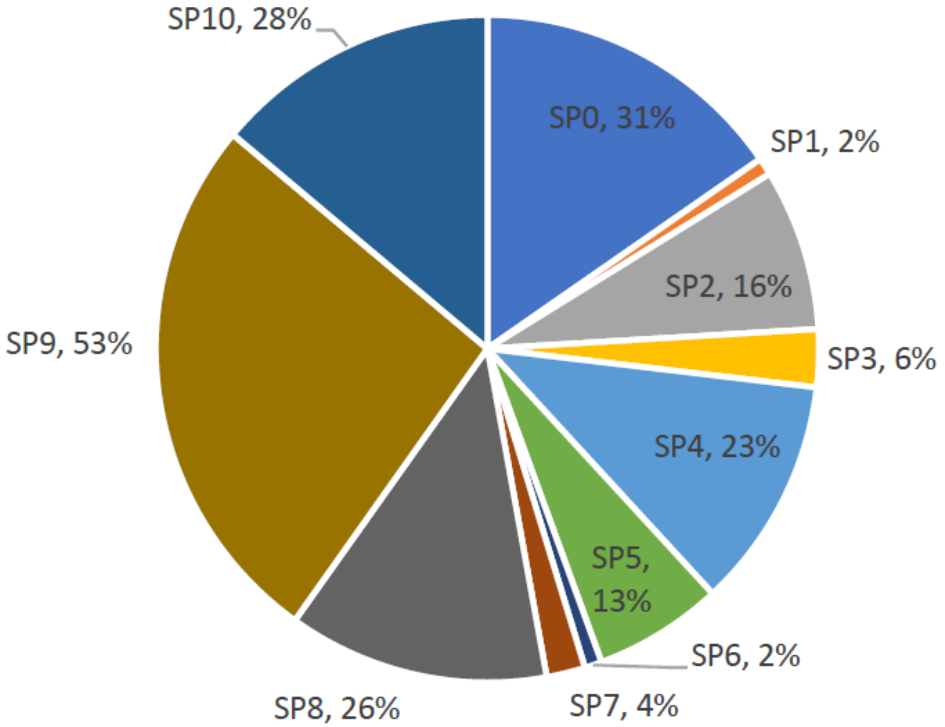
Statistics related to EHSP identified safety principles (SP#)





https://www.fch.europa.eu/sites/default/files/documents/Safety_Planning_Implementation_and_Reporting_for_EU_Projects-Final.pdf

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Structure of recommendations at a glance

Table 3: Structure of the recommendations at a glance

Recommendations	Operational mode		
	Industrial sectors	Hydrogen energy	H_2 transport and distribution
			H_2 powered vehicles
			Laboratory / R&D
			Power generation
		Other industrial sectors	*Nuclear*
			Aerospace
			Chemical/petrochemical
	Human factors		

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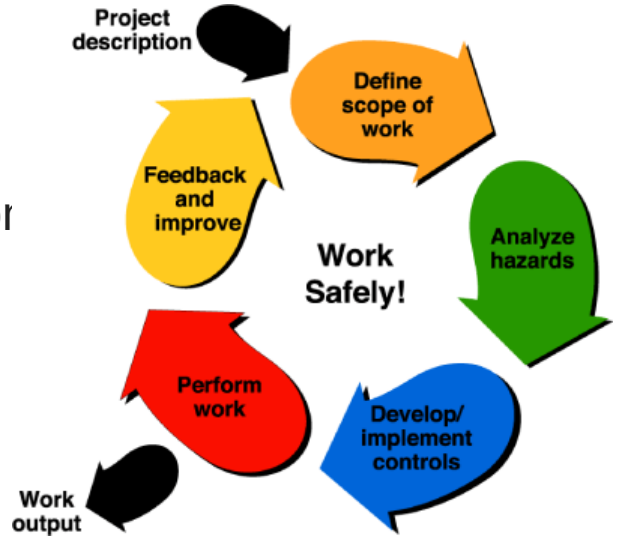
Recommendations for different operational modes

- Adequate training of personnel is key (SP9) - training of new personnel as well as periodic updated training of existing personnel.
- Both passive and active safety measures should be appropriately considered (SP7, SP8).
- Leak detection (SP4) and ATEX zoning (SP3, SP5) should be applied to improve safety.
- Regular inspection and maintenance.
- When operational/equipment changes are made, the maintenance/inspection should also be updated accordingly.



https://eta-safety.lbl.gov/content/integrated-safety-management-ism

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Recommendations for hydrogen energy applications – system design

- Perform Process Hazard Analysis for any new/updated installations (SP1-10);
- Use materials which are compatible with hydrogen services. In some incidents, such problem resulted in the need to change standards and codes for pressure vessels (SP0);
- Install adequate leak detection and mitigation barriers (SP4, SP8) for critical systems.

https://risk-engineering.org/safe-design/

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THANK YOU!

The report from the analysis can be found at https://www.fch.europa.eu/sites/default/files/documents/Lessons%20learnt%20from%20HIAD%202.0-Final.pdf

A paper based on the analysis was presented at the International Conference on Hydrogen Safety 2021 and awarded the best paper prize.

A modified version of the above paper has been published in the International Journal of Hydrogen Energy in Gold Open Access. It can be downloaded free at the following link:

https://reader.elsevier.com/reader/sd/pii/S0360319922012976?token=B67B5AC502387E7B7CE7CC15DABAE2731A101F1BEF7D7A2DEDBF4B0DE060A2CD430485A0C110D758A00ADE1D884ADF5D&originRegion=eu-west-1&originCreation=20220414145607