EXSOLUTION-BASED NANOPARTICLES FOR LOWEST COST GREEN HYDROGEN VIA ELECTROLYSIS

EXSOTHyC

Risk analysis and safety planning

(Deliverable D7.2)

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NOTICES

For information, please contact the project coordinator, Mari Šavel, e-mail: mari.savel@stargatehydrogen.com. This document is intended to fulfil the contractual obligations of the EXSOTHyC project, which has received funding from the Clean Hydrogen Partnership and its members, concerning deliverable D7.2 described in contract 101137604.

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Table of revisions

Version	Date	Description and reason	Author	Affected sections
V0.1	18.06.2024	First draft created	Mari Šavel	All
V0.2	28.06.2024	Document elaboration	Mari Šavel	All
V0.3	03.07.2024	Finalising safety planning	Mari Šavel	Section 5
V1.0	17.07.2024	Review	Rainer Küngas	All

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List of Partners

Stargate Hydrogen Solutions OÜ (Stargate)
University of St Andrews (St Andrews)
Agfa-Gevaert NV (AGFA)
Eindhoven University of Technology (TUE)
Fraunhofer IFAM (IFAM)

List of Abbreviations

AST – Accelerated Test Protocols

CCD – Catalyst Coated Diaphragm

EU – European Union

HTO – Hydrogen To Oxygen

JU SRIA – Joint Undertaking Strategic Research and Innovation Agenda

KPI – Key Performance Indicator

PEM – Proton Exchange Membrane

T – Task

WP – Work Package

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1 Introduction

The EXSOTHyC project aims to optimise electrolyser operation towards lower voltages and higher efficiencies by combining electrodes made using powder metallurgy with ceramic nanoparticles fabricated by exsolution. To achieve this the project proposes alternative pathways to the O_2 and H_2 evolution reactions by new anode and cathode approaches; novel concepts of membrane electrode assemblies with integrated components; and a novel cell design to enhance overall cell efficiency by integrating disruptive concepts.

There are no specific risk assessment requirements for implementing the project as it concerns developing different components and design of an alkaline electrolysis stacks. And as this is a Research and Innovation Action project with no hydrogen production, storage, or distribution and use of hydrogen activities, the consortium does not see any direct hydrogen safety concerns. However, it is utmost important to develop a proactive approach to risk management, ensuring alignment with project objectives, enhancing stakeholder confidence, and increasing the likelihood of successful project outcomes. By understanding and addressing these risks early, we aim to optimize resource allocation, improve project performance, and ensure compliance with funding requirements.

In this document, we introduce the safety planning methodologies used at the EXSOTHyC project partners for the internal safety activities.

2 Objectives

The main objective of the deliverable is to provide an overview of identified potential safety vulnerabilities, hazards and associated risks together with risk management and mitigation measures.

In this document, a first set of risks has been identified, yet the risks will undergo continuous assessment throughout the lifecycle of the EXSOTHyC project. We systematically identify, assess, and mitigate potential risks that could impact optimising electrolyser operation towards lower voltages and higher efficiencies within the scope of EXSOTHyC.

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3 Methodology

It is to be noted that each partner has their own health and safety procedures defined, which can be provided upon request. Below we present the overall approach for risk management within the project.

3.1 Risk identification process

For a successful risk management, we need to be able to identify any potential risks. The following issues shall be considered as tools and techniques for risk assessment and identification:

- Analysis of deliverable status
- Analysis of WP schedules and scopes
- Regular communication between the Coordinator and the WP leaders.

A schematic representation of the risk management process is shown in Figure 1.

The risks will be collected in a Risk Assessment Table by the Project Coordinator. This register is accessible to all members through the EXSOTHYC SharePoint.

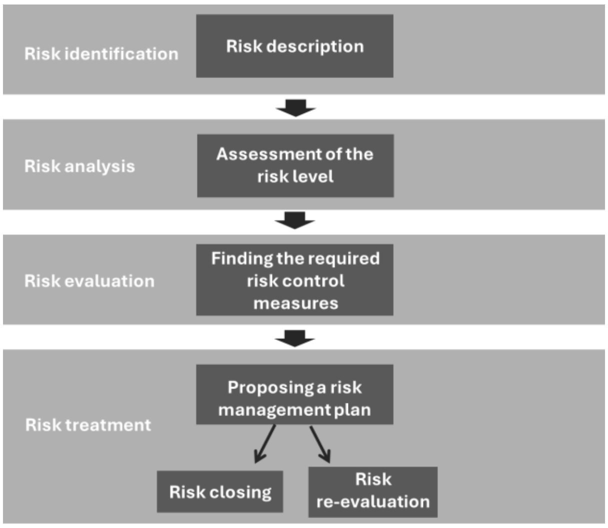

Figure 1 Risk Management process

3.2 Risk analysis

Risk analysis foresees assessing the probability and impact of the potential project risk on a scale: low, medium, and high. For example, a risk with a high probability and high impact will be considered a critical risk. A risk matrix, shown in Figure 2, will be utilized to plot and prioritize risks based on these criteria. Additional factors such as detectability and proximity could also considered during the risk analysis.

The Project Coordinator, in collaboration with the WP leaders, will estimate the probability of the risks at different times during the project lifetime.

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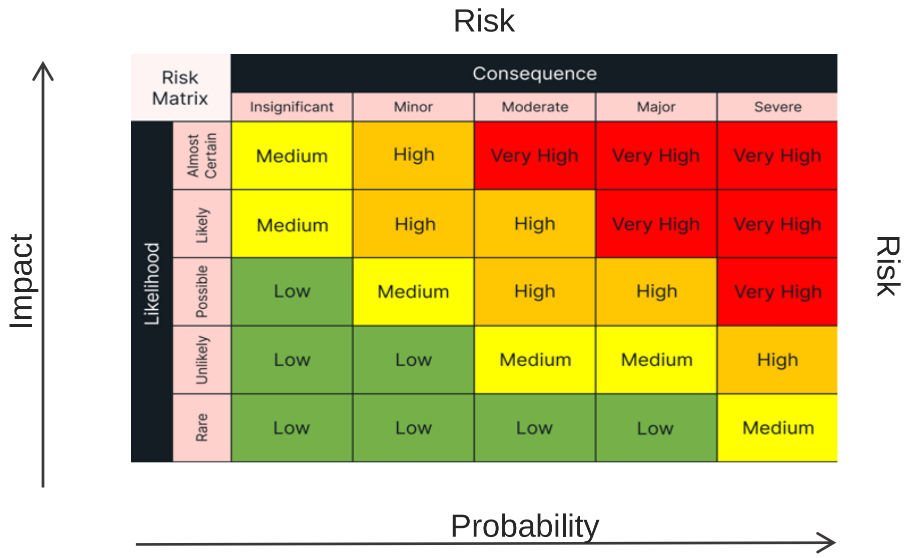

Figure 2 Risk matrix

3.3 Risk evaluation

It is the responsibility of all partners to openly communicate to the WP leaders or Project Coordinator about the status and effectiveness of potential risks and respective mitigation measures. Risk exposure will be continuously re-evaluated and modified accordingly. If any new risks are identified by a partner, they will be analysed as those on the original risk list and then added in the register.

The WP leaders and the project coordinator regularly review the list of risks and during the face-to-face meetings, the list will be reviewed by the entire consortium.

3.4 Risk treatment

Risks will be prioritized based on their combined probability and impact scores. A scoring system will be used for ranking risks from highest to lowest priority. Critical risks requiring immediate attention will be highlighted and escalated to the project management team for prompt action. All identified risks will be documented in a risk register, which includes the following details:

Risk no	Risk description	WP	Probability (low/medium/high)	Impact (low/medium/high)	Mitigation	Month risk detected	Status update

The risk register will be reviewed and updated regularly according to the need, but no less than once a year.

As defined in the D7.3 Quality Assurance deliverable, each party is responsible for executing the risk mitigation activities which relate to the task or WP they lead. If a mitigation action cannot be effectively carried out or does not solve the risk, the risk exposure is likely to become more important. In this case, visibility of the risk must be highlighted by the Project Coordinator and the mitigation measure reviewed. An item can be considered closed when it is no more likely to happen. In this case it is ranked as low and reported respectively in the register.

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4 Identified critical risks for implementation

4.1 Risks identified prior the project start

Before the project start, we have carried out a risk assessment for the EXSOTHYC project about the potential critical implementation risks that may occur during the project lifetime. So far, none of these risks have occurred.

Risk no	Risk description	WP	Probability (low/medium/high)	Impact (low/medium/high)	Mitigation	Month (risk detected)	Status update
1	Ink formulation and electrode development using exsolved materials is more difficult than anticipated.	1	MEDIUM/LOW	MEDIUM	Starting with ink development activities early in the project, simultaneously with material development		
2	Exsolution of alloy nanoparticles cannot be carried out on powder metallurgy electrodes.	1	MEDIUM	MEDIUM	Fall back to conducting exsolution of the ceramic material before the electrode fabrication step and then depositing already exsolved materials onto the electrode		
3	A combination of ceramic particles and a metallic substrate is not possible.	1	MEDIUM	HIGH	Adjustment of manufacturing method (wet/ dry process). Adjustment of heat treatment (calcination parameters), powder pre-treatment		
4	Ni-nanostructure will be affected during electrode manufacturing (powder application or heat treatment).	1	HIGH	HIGH	To circumvent the temperature-induced damage of the nanostructure, two different ways for electrode manufacturing are proposed, one of which aims at avoiding high temperatures		
5	EC results do not reflect expectations.	1	MEDIUM	MEDIUM	Iterative adjustment of powder manufacturing parameters and consolidated electrodes		
6	Problems with the stacking of the produced electrodes (layer flakes off, insufficient strength, etc.).	1	MEDIUM	MEDIUM	Iterative adjustment of the manufacturing parameters of the coated electrodes		

7	A sufficient conductivity within the electrode cannot be reached.	1	HIGH	HIGH	To increase conductivity carbon or metallic particles are added to exsolution material		
8	A stable non-PGM recombination catalyst cannot be identified.	2	MEDIUM	LOW	Fall back to Pt as recombination catalyst, at loadings well below the KPI of the Clean Hydrogen JU SRIA of 0.3mg/W		
9	The recombination catalyst has a minor impact on HTO.	2	MEDIUM	LOW	Focus T2.2 on coating a polymeric layer onto Zirfon, which acts as a hydrogen/oxygen barrier, achieving reduced HTO and thus meeting the WP objective		
10	A combination of catalyst particles and binder is not suitable for CCD due to instability.	3	MEDIUM	LOW	Adjustment spraying ink preparation by varying solvent and binder choice		
11	CCD is not conductive enough to ensure the catalytic activity of the nanoparticles.	3	MEDIUM	MEDIUM	Adjustment of spraying parameters during the spraying process. Use of blade coating technique to ensure low surface roughness and uniform layer formation		
12	Performance targets using the CCD approach not achieved.	3	MEDIUM	MEDIUM	Pt doping at low levels of cathodic CCD layer to ensure good catalytic activity and low cell potentials		
13	The reverse current model is unable to properly predict potentials in laboratory short-stack.	4	LOW	MEDIUM	Include the empirical fitting in the model		
14	Impedance spectroscopy will give less information than hoped for (e.g. due to noise or overlapping semicircles.	4	MEDIUM	LOW	The implementation of a reference electrode can increase the information that can be obtained from the impedance measurements		
15	None of the new electrode materials has a good performance in the accelerated stress test.	4	LOW	MEDIUM	The electrode materials will be further optimized to enhance their stability (WP2)		
	Cell testing under industrially relevant conditions (at least 5 bar, 30% KOH, 80+ degrees C) fails to identify the test objectives.	5	LOW	MEDIUM	Extensive testing of all subcomponents will be performed in WP1-3 in advance to find the best-performing solutions. Proper documentation of the tests and		

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					publications dealing with the tests will make the impact smaller if the risk becomes true.		
	Scale-up difficulties delaying the prototype construction.	1-5	LOW	MEDIUM	The risk will be mitigated through the relatively long integration and validation period.		
	A stack test combining all the proposed solutions fails to achieve project performance targets.	5	MEDIUM/HIGH	HIGH	Stack development is a stepwise process. The development starts with small-scale subcomponents in order to reduce time and cost for potential failures. Corrective methods for misalignments will be developed and applied for achieving the targets.		

4.2 Risks identified after the project start

Currently no new risks have emerged

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5 Health and Safety planning

Besides the critical implementation risks listed in Section 4, each partner will constantly analyse potential safety vulnerabilities, hazards and associated risks which may occur while they are implementing their project tasks and WPs. The analysis will be performed for the technical WPs only as the dissemination and management work packages (WP6 and WP7), where all partners are involved, do not present any physical risks.

Identification of safety vulnerabilities, hazards and risks assessment can be done using any of the established, standardised industry methods. These methods shall help the partners identify potential safety issues, discover ways to lower the probability of an occurrence and minimise the associated consequences in an incident that could happen.

5.1 Potential incident scenarios

As described in section 1, the project does not deal with hydrogen demonstration, but develops a novel alkaline electrolysis stack with novel components. Main activities are related to production of electrode materials and electrode development (WP1), Zirfon with reduced gas cross-over (WP2), CCD development (WP3), dynamic operation stability (reverse current model, cell characterization, AST. WP4) and building a short stack prototype (WP5).

The potential incident scenarios can therefore be related to electrical, chemical, pressure, thermal, and physical risks to be handled by the corresponding personnel. Potential mitigation measures for these are as follows:

Electrical: The appliances must be regularly serviced and used in accordance with the manufacturer's instructions.

Chemical: Always wear the prescribed body protection: Nitrile gloves, goggles, lab coat and safety shoes.

Pressure: Protective wall between operator(s) and the stack. The test system must be fitted with an overpressure valve. System shall be manually vented. The system shall be fitted with an analogue pressure gauge to avoid user error.

Thermal: Protective wall between operator(s) and the stack. Test system cabinet must be closed during operation. Hot surfaces must be insulated. Heat resistant gloves required when working near hot surfaces.

Physical: Always wear a helmet, safety shoes, gloves and goggles. Establish safe clearance from heavy objects. Heavy objects shall always be lifted only by personnel with adequate training, with suitable equipment, and never alone.

The involved labs conform with ISO 9001:2019 standard. All the staff involved in the EXSOTHyC are well trained, have experience and knowledge specific to the set of related processes, equipment, and facilities. Each partner has for every procedure, including any risk, corresponding procedures and applicable health and safety guidelines in place which can be provided upon request. Each partner has also assigned Health and Safety representatives. Hazard/risk assessments are carried out on the basis of which the appropriate protective measures are determined.

6 Conclusions

As the project progresses, it is essential to remain alert for potential emerging risks and the risk management plan should be adaptable, allowing for modifications based on new information. Continued regular risk assessments will be key to maintaining project resilience.

In conclusion, this risk analysis provides a robust framework for identifying, assessing, and mitigating risks throughout the project lifecycle. By implementing the recommended strategies and maintaining an adaptable approach to risk management, we can enhance the likelihood of project success and achieve our objective of advancing the PEM-like efficiency of alkaline electrolysers.

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