CENTER FOR Hydrogen SAFETY
Connecting a Global Community

HYDROGEN Safety Panel

Hydrogen Incident Recovery Guide

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Scope

This document applies to the **recovery phase** of a typical emergency management frameworkthat includes planning, response, mitigation, and recovery.[1,2] This document provides practical guidance with a checklist to help an organization recover from a hydrogen incident and return to normal operations after the event scene has been stabilized and returned to the organization by the incident commander. This document does not include activities related to the immediate emergency response and initial investigations performed by other entities. Depending on the severity of the incident, this guidance can be tailored to meet the specific needs of the organization.

[1] U.S. Department of Homeland Security, *National Response Framework*, Fourth Edition, October 2019.
[2] U. S. Department of Energy, DOE G, 151.1-1A, *DOE Comprehensive Emergency Management System,* July 2007.

1. Introduction

The checklist in this guide implements the recovery process, including the spectrum of activities performed in the near (weeks) to longer term (months and years). The organization's recovery process should be coordinated with other entities that may have jurisdiction of the scene. The activities needed to recover are dependent on the extent of damage from the incident, and not all steps in the checklist may be needed. This guide may be used to supplement an organization's existing procedures.

The checklist (Section 2) helps to guide the organization through the recovery process:

- **Status** is provided for users to check off steps when completed.
- **Recovery Topics** describes a sequence intended to make the process more easily understood; actions do not need to be completed in the order presented; and multiple actions can be taken at the same time.
- **Interfaces** identifies steps where communication with other organizations is recommended. The numbers refer to specific organizations in Note A that would interface with the recovery coordination team's point of contact. Frequency of interface is dependent on conditions and necessity.
- **Appendix Reference** identifies appendices and sections of this guide where additional information on the recovery topics can be found.

2. Recovery Topics

Status	Recovery Topics	Interfaces (Note A)	Appendix Reference
	1. ESTABLISH/ACTIVATE a recovery coordination team		E.1
	a. IDENTIFY members of recovery coordination team		A
	b. IDENTIFY points of contact for external communication		B
	c. OBTAIN initial post-event briefing from organization management and/or first responder lead	(i)	
	d. COMMUNICATE post-event briefing to appropriate individuals	(i) (ii) (iii) (iv) (v) (vii)	E.2
	2. VERIFY incident scene is safe, contained, and secured, and evidence is preserved		E.3
	a. PRESERVE incident scene by signage and physical barriers		
	b. RESTORE basic infrastructure utilities to site (electricity, water, heating, ventilation, air conditioning, plumbing, etc.) as needed and when safe to do so without affecting preservation of event scene evidence		

Status	Recovery Topics	Interfaces (Note A)	Appendix Reference
	c. ESTABLISH access control process for authorized personnel and equipment entering and exiting controlled/secured scene		
	d. COMMUNICATE security expectations with appropriate individuals	(i) (iii) (iv) (vi) (viii)	E.2
	e. COORDINATE with law enforcement or other agencies if a crime or act of terrorism is involved	(v)	E.2
	f. If needed, COORDINATE with other government agencies, such as occupational safety, health, and chemical safety agencies	(v)	E.2
	g. IDENTIFY physical and digital assets that need to be retrieved or recovered		
	3. DETERMINE safe conditions and reentry requirements using guidance in Appendix C	(i) (iii) (v) (vi) (vii)	E.4
	a. ESTABLISH reentry team of at least two persons		
	b. PROVIDE safety briefing to reentry team(s) to address activities, tasks, hazardous materials, protective clothing and equipment, communication protocols, emergency evacuation routes, evidence preservation, and assigned objectives		
	c. COORDINATE reentry work plan with appropriate individuals	(i)	
	4. CONDUCT internal investigations		E.5
	a. ESTABLISH internal investigation team		
	b. ENGAGE with external experts (technical experts, Hydrogen Safety Panel, consultants, etc.)		
	c. PRESERVE, COLLECT, DOCUMENT, and ORGANIZE evidence (Note: Make sure scene and evidence are preserved)		E.3, E.5.2.(2)
	d. DOCUMENT results of investigation		
	e. COMMUNICATE results of investigation with appropriate individuals	(i) (ii) (iii) (iv) (v) (vi) (vii)	E.2
	5. CONDUCT root cause investigation		E.5.3
	a. ESTABLISH root cause analysis team, if separate from the investigation team		
	b. COORDINATE root cause analysis with internal investigation team (Note: If collecting data or entering scene, make sure scene and evidence are preserved)		

Status	Recovery Topics	Interfaces (Note A)	Appendix Reference
	c. COMMUNICATE results of root cause analysis with appropriate individuals	(i) (ii) (iii) (iv) (v) (vi) (vii)	
	6. INITIATE/COMPLETE restoration activities		E.6
	a. REPLACE emergency response supplies		
	b. PERFORM cleanup activities		
	c. PERFORM repair activities		
	d. IDENTIFY, REPLACE, and TEST safety devices		
	e. COORDINATE with individuals as necessary	(i)	
	7. DOCUMENT FINAL report		E.7
	a. INCORPORATE internal investigation report		
	b. INCORPORATE root cause analysis, if separate from the investigation report		
	c. INCORPORATE insurance claims report, if available		
	d. IDENTIFY corrective actions taken and planned		
	e. DISCUSS lessons learned		
	8. IMPLEMENT corrective action(s)		E.8
	a. PERFORM equipment and process changes based on internal investigation report and root cause analysis		
	b. REVISE facility procedures, if necessary		
	c. TRAIN appropriate organization and others outside the organization, as needed, on changes to the facility and procedures		
	d. TRACK completion and validation of the procedure changes and modification(s)		
	e. COMMUNICATE modification(s) to organizations, as appropriate	(i) (iii) (iv)	
	9. PERFORM safety startup operations		E.9
	a. COMPLETE operational readiness assessment for affected systems		D
	b. COMMUNICATE readiness status to organizations, as appropriate	(i) (ii) (iii) (iv) (vii)	
	10. SHARE information with external organizations, as appropriate	(i) (ii) (iii) (iv) (v) (vii)	E.10

Status	Recovery Topics	Interfaces (Note A)	Appendix Reference
	11. PERFORM final close-out activities		
	a. VERIFY internal investigation is complete		
	b. VERIFY root cause analysis is complete		
	c. VERIFY lessons learned are incorporated, as appropriate		
	d. VERIFY insurance company investigation is complete		
	e. VERIFY all corrective actions are complete or tracked to completion		
	f. DISBAND the recovery coordination team		

Notes:
(A) Interface Organizations:
i. Organization reps
ii. Media
iii. Insurer
iv. Hydrogen expert panel
v. Local and federal agencies
vi. Legal
vii. Affected community groups
viii. Forensics experts

Appendix A – Recovery Coordination Team Contact List

Role	Name	Phone	Email
Recovery Coordination Team Leader			
Emergency Preparedness			
Human Health, Safety, and Environmental			
Facility Operations			
Design Engineering			
Systems Engineering			
Security			
Vendor Contact			
Hydrogen Experts			
Legal Counsel			
Public Relations			
Others			

Appendix B – Points of Contact for External Communication

External Communication Contacts	Name	Phone	Email
Insurance			
Extern Legal (Casualties)			
Local Agencies			
Federal Agencies			
Social Media			
Law Enforcement			
Federal Bureau of Investigation			
Local Newspapers, Television			
Others			

Appendix C – Reentry Condition Checklist

This checklist serves as a damage assessment tool to assist in identifying the reentry conditions. Appropriate trained and qualified individuals (e.g., licensed structural engineer, civil engineer, mechanical engineer) may be required, depending on the level of damage.

Facility Element	Status
Structural Components	
Exterior Walls	
Interior Walls/Floors	
Ceilings/Roofs	
Utility/Vital Services	
Electricity	
Water	
Gas/Oil/Steam	
Telephone	
Sewage	
Network/Data/Transmission/Internet	
Critical Systems	
Hydrogen Transfer Systems	
Hydrogen Storage Tanks	
Hydraulic Systems	
Air/Ventilation Systems	
Safety Alarm and Monitoring Systems	
Security Systems	
Other Systems	
Hazards	
Other Hazardous Chemicals	
Occupation	
Can be occupied as is?	
Can be occupied after minor recovery effort?	
Can be occupied after major recovery effort?	
Cannot be occupied (recommend demolition)?	

Appendix D – Operational Readiness Assessment Example

Note: A detailed checklist to verify system readiness should already be part of a facility's system maintenance program. Use multiple assessment forms for multiple systems, if needed.

SYSTEM NAME:

SYSTEM PURPOSE:

ASSESSMENT TEAM:

ASSESSMENT OVERVIEW:

EXCEPTIONS TO READINESS:

Examples include:

- ✓ *Equipment/component is not functioning properly*
- ✓ *Equipment/component is the wrong type or not listed for the intended use*
- ✓ *Procedure changes have not been completed or validated*

STATEMENT OF READINESS:

Examples include:

- ✓ Corrective actions implemented and validated (e.g., procedure changes and design changes).
- ✓ Confirm system components that were replaced are fully operational and performing their intended design functions.
- ✓ Confirm unnecessary equipment/tools have been removed from the repair areas.
- ✓ Confirm regulatory approval is obtained, if required.

Approvals

Recovery Coordination Team Manager: _____ Date: _____

Operations Manager: _____ Date: _____

Appendix E – Background Information on Recovery Topics

E.1 Establish a Recovery Coordination Team

A recovery coordination team should be defined (positions, responsibilities, procedures, etc.) as soon as possible and no later than at the conclusion of the initial response phase. Team members should have basic training on investigation and recovery, hydrogen hazards, and other chemical hazards. The recovery coordination team will identify, organize, lead, and implement the activities necessary to return the affected facilities and surrounding areas to pre-emergency conditions. If applicable, the recovery coordination team will also support offsite recovery efforts led by local and federal agencies. The recovery activities may be planned before the emergency is over but should not divert resources from the initial incident response.

The individuals that make up the recovery coordination team will vary depending on the severity of the incident; however, members frequently include representatives from the following groups within the organization:

- Recovery coordination team leader* (determined by the organization's management)
- Emergency preparedness
- Human health, safety, and environmental
- Facility operations
- Design Engineering or Systems Engineering
- Other supporting groups, such as Public Relations/Communications and Security
- Other site-specific departments

The recovery coordination team has the following key responsibilities, which are normally assigned by the recovery coordination team leader:

- Create, update, and execute a recovery plan
- Preserve and sustain the incident scene to support investigations
- Collect information to support recovery communication
- Provide internal communication to staff and personnel regarding loss, work suspension, and compensation
- Provide external communication to stakeholders and the public about risk mitigation and recovery progress
- Maintain a liaison with local and federal agencies and authorities having jurisdiction
- Maintain a liaison with the organization's insurance provider(s)
- Conduct damage assessment and estimate cost and schedule for recovery
- Conduct investigations to support applicable insurance claims, regulatory compliance, and other requirements
- Conduct repairs and prepare for reentry
- Restore operation
- Ensure post-incident information sharing, including lessons learned

The recovery coordination team should remain in place as long as necessary to return the organization or facility to normal operations. When it is determined that recovery activities are no longer necessary, the recovery coordination team lead should ensure that a turnover of all work completed and actions to be continued is provided to the appropriate facility organizations and terminate the activities of the recovery coordination team. The responsibility for activities such as engineering; safety, health, and environmental; and operations should be transitioned as soon as possible. The recovery coordination team will be responsible for developing the lessons learned that will identify activities that worked well and those that could benefit from improvements in the future.

E.2 Manage Communication

Depending on the extent of impact, full recovery from a hydrogen incident may take days, weeks, months, or even years. Interfacing with internal and external entities to communicate the status of recovery may be required or prudent. Provide accurate information to the local and federal communities and agencies, insurance providers, the media, and the hydrogen expert panel to minimize the public's anxiety and concerns. Maintain timely and periodic communication with these agencies and the media as the organization recovers from the incident.

Communication protocols generally initiated during the initial response activities may continue throughout the recovery activities. The recovery coordination team determines what information is ready and appropriate to communicate, including to whom and when to communicate the information. Figure 1 lists the different types of information generally communicated to different organizations, which are discussed in the bullets below.

- **Post-Event Briefing:** The primary targets for this briefing are organization representatives and workers, local and federal agencies, insurance companies, and the hydrogen expert panel. The goal is to share what is immediately known about the event at a high level since many of the details may not be known until an investigation is completed. Provide information that is known and factual about the incident, including the impact to workers and the public and the current condition of the facility. For example, has the event been stabilized or is it still in the process of being stabilized?
- **External Communications:** The focus here is on the media and affected local groups. Depending on the severity of the event, media inquiries may be local or national. Provide information that is known and factual about the incident, which can help alleviate unwarranted fear among the public.
- **Investigations:** Identify who will be on the investigation team while noting internal and external or third-party experts. Provide a brief overview of the investigation scope and the fact-finding process.
- **Facility/Operations Modifications:** Describe how the facility was stabilized and any modifications planned or completed to the operational process to prevent potential future incidents.
- **Final Reporting:** While many entities may be interested in the final report, it is important to communicate the findings and outcome via a press briefing and provide a copy of the report to appropriate local and federal agencies. The final report can be an excellent tool

to share lessons learned with the hydrogen safety community and alleviate similar incidents in the industry.

- **Implementation of Recommendations:** Share with the hydrogen safety experts which recommended findings were corrected to prevent or minimize the potential for future incidents. Sharing lessons learned and corrective actions taken is crucial to preventing similar incidents, promoting and maintaining a safe hydrogen industry, and alleviating any undue fear among regulators and the public.

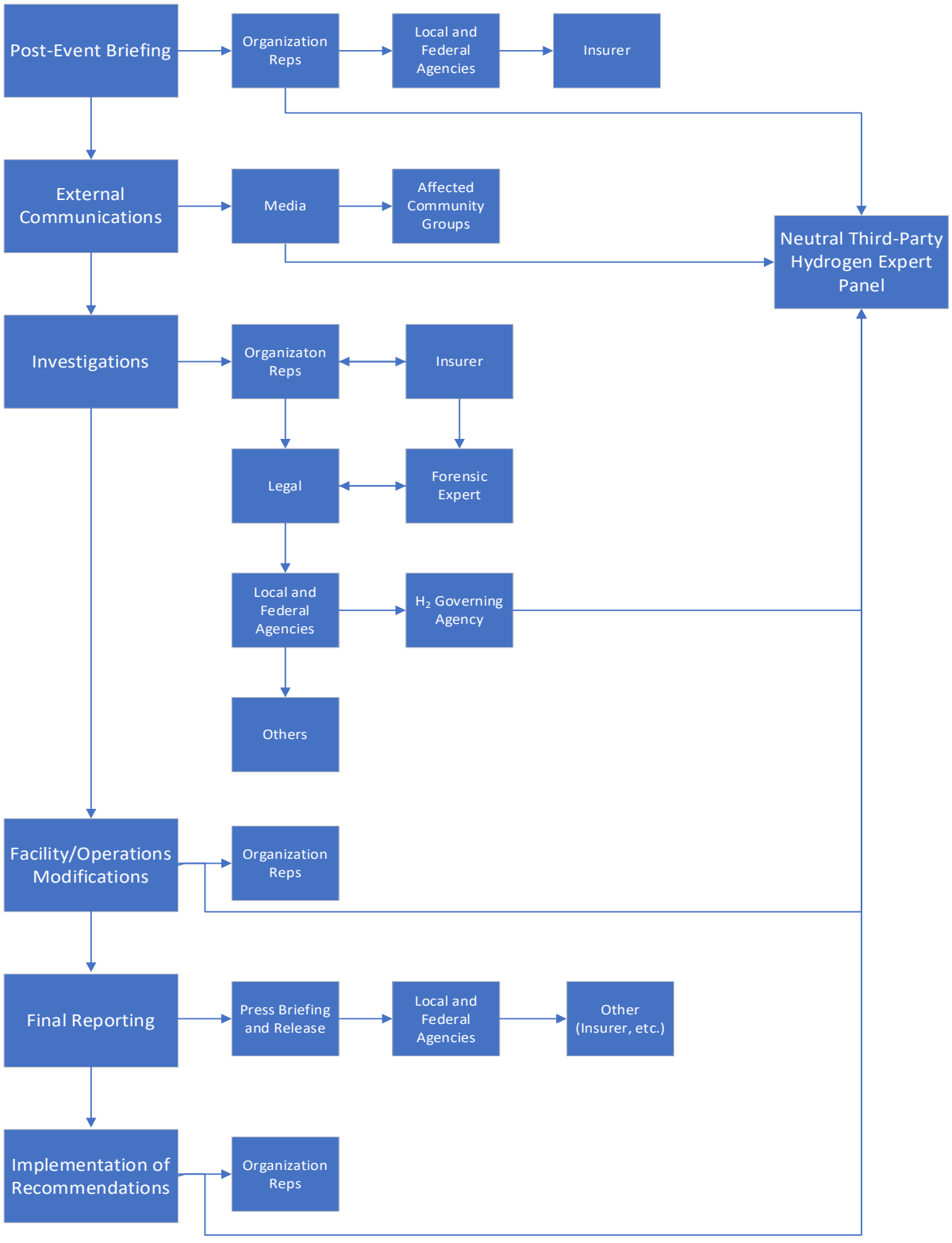

Figure 1. Example of Post-Incident Communications

E.2.1 Interface with Internal and External Stakeholders

Communications with stakeholders internal and external to the affected organization would be necessary to address regulatory and legal requirements or expectations. Typical internal and external stakeholders include:

- **Organization leadership** to report on progress of recovery actions
- **Loss prevention/insurance department** to coordinate with insurance provider(s) to identify extent of liabilities and payment obligations
- **Regulatory compliance** to report to local, state, and/or federal agencies
- **General counsel/legal department** to addresses casualties, injuries, or other liabilities from the incident
- **Systems and design engineers** to determine root cause of the incident and identify corrective actions
- **Operations** to ensure continued safe operations of the facility
- **Procurement/spare parts** to obtain required equipment to return facility back to safe operations
- **Human resources department** to assist with employee interviews and to ensure post-traumatic stress counseling is available to employees
- **Public works** (electrical, water, telecommunications, gas/fuel, wastewater/ sewage, etc.)
- **Medical facilities** (hospitals, urgent care facilities, etc.)
- **Employees** to communicate lessons learned and corrective actions

Contact the organization's insurer(s) and general counsel immediately after stabilizing the scene. General counsel will provide advice on how to proceed, what information to communicate, and to whom. The organization's insurer(s) will begin documenting the scene for the claims process. Depending on the level of incident, government officials may get involved, and/or a civil lawsuit may be possible. Both general counsel and the organization's insurer(s) may influence the overall timeline and may advise during the recovery process. Ensure investigation activities by other entities are completed before initiating cleanup activities.

E.2.2 Interface with the Public/Social Media

The goal is to reliably inform the public and ensure consistent and technically accurate information is presented to maintain credibility with the audience. Examples of methods to inform the public include physically going door-to-door to inform nearby residents/businesses, announcement/discussions through nearby community centers, and use of social media platforms. Regularly update the industry on the event and recovery status it unfolds. The Nel

Hydrogen's Kjørbo incident[3] status updates are a great example of a well-executed public relations strategy. Normally, an organization's general counsel may advise on what information is appropriate to present as part of the public relations strategy. Using non-technical terms, address the following topics (use of visuals may be helpful):

- What occurred
- Extent of damage/impact
- Human and social consequences (e.g., number of fatalities or injuries, adults, or minors)
- When it is safe to resume operation
- Why the facility is safe for recovery
- If appropriate, share the recovery process (appointing recovery coordination team, investigation, root cause, etc.)

E.2.3 Interface with Technical Experts and Hydrogen Safety Community

Interface with teams of technical experts, such as the Hydrogen Safety Panel[4] or other subject matter expert groups, such as vendors and hydrogen specialists, for help with different types of situations as they are encountered. Examples of organizations to interface with include but are not limited to the following:

- Vendors on safe system operation
- Hydrogen safety experts for independent reviews and insights on investigation results
- Others, such as occupational safety, health, and chemical safety agencies, to discuss safety related issues

E.2.4 Coordinate with Law Enforcement Agencies

If the cause of the incident is suspicious or terrorist related, it will be necessary to coordinate with local, state, and/or federal law enforcement agencies, such as the local police department, sheriff's office, and Federal Bureau of Investigation.

E.3 Manage the Incident Scene

Preserving the incident scene, evidence, and facilities is important for supporting incident investigation, legal requirements, and preparation of operational resumption. Outside of securing the safety of the scene, DO NOT disturb or clean up anything, as this may hinder the investigation. Key considerations include the following.

- **Preserve the incident scene and equipment/components:** Display signage and set up physical barriers (e.g., fences, boom barriers, gates, caution tape) as needed to

[3] Information on the Nel Hydrogen Kjørbo incident can be found at https://nelhydrogen.com/status-and-qa-regarding-the-kjorbo-incident/
[4] https://h2tools.org/hsp

isolate the scene of the incident. Deploy security personnel if necessary to preserve the scene and guard against trespass. As needed, provide pest control to preserve the scene.

- **Restore basic utilities:** As needed and when safe to do so, contact building/facility owners and authorities having jurisdiction to restore necessary utilities, such as electricity, running water, plumbing, heating, ventilating, and air conditioning systems, to support incident scene preservation.
- **Control site access:** Determine and authorize site access to facilitate investigations and other recovery actions. Identify the individuals, organizations, and conditions for access authorization. Create an access-control list (ACL) and communicate the ACL and access authorization requirements (e.g., special permits or other artifacts and required identification documents) to relevant personnel. Provide the ACL to security personnel in charge of scene preservation and maintain an access log to ensure only approved personnel can access the incident scene.
- **Recover organizational assets:** Identify assets left at the incident scene that need to be retrieved and recovered. Such assets could include physical assets (e.g., personal effects, cash, equipment) or digital assets (e.g., organizational data, computer network data). In particular, it is important to identify assets that can help the recovery coordination team establish an operational baseline and identify recovery goals and target completion dates for corrective actions. Do not recover organizational assets until agreement is obtained from the authorities and the organization's insurer and legal team.

E.4 Determine Safe Conditions and Reentry Requirements

Reentry is the act of reentering an evacuated area to assess facility conditions in order to determine the extent of recovery activities to allow for safe reentry. Determine the reentry requirements such as personal protective equipment, hazardous materials that could be present, and the need for monitoring equipment, and assess the integrity of the structures to determine if they are stable or need repairs. Reentry into the scene by organization representatives should be coordinated with the insurance company and their forensic experts and legal entity(ies) prior to entering the incident scene. The following outline provides guidance on determining reentry activities:

(1) Determine the objectives of the reentry activity.

Perform a checklist of all damage assessment considering the items as applicable, such as condition of structural components, infrastructure (e.g., water, electricity, communications, etc.), critical facility systems, and other fire hazards. An example of a checklist of items is included in Appendix C.

(2) Determine the composition of reentry team(s) based on the objectives and special considerations, as identified from the checklist.

- A team should consist of at least two persons.
- The reentry team should include individuals whose expertise is specifically suited to the type of work to be accomplished and who have received appropriate training.

- If the event is confirmed or suspected to involve other hazardous chemicals, the team should include an industrial hygienist or other individual who has knowledge and expertise in the hazards.

(3) Ensure reentry teams are provided a safety briefing on the following topics as applicable:

- Activities to be performed
- Job safety analysis for specific task assignments
- Areas to be surveyed
- Other hazardous materials that could be present
- Hazardous material monitoring equipment required
- Protective clothing and equipment required
- Communication protocols
- Emergency evacuation routes
- Evidence preservation requirements
- Reporting completion of assigned objectives

E.5 Conduct Investigations

The recovery coordination team will normally coordinate the performance of a formal investigation to understand what happened and why. Investigation team members should also have basic training on investigation, hydrogen hazards, and other chemical hazards. The individuals performing the formal investigation will need to understand the importance of preserving the scene and data collected (see Section E.3 for additional guidance). The recovery coordination team may also designate a dedicated group of individuals to perform the formal investigation based on the extent of condition.

Formal investigation of an incident is a fact-finding process to assess the extent of damage and potential causes of the incident. The investigation will typically involve organization representatives, technical experts on hydrogen safety, insurance adjusters, and possibly federal agencies, as appropriate. A formal root cause analysis (RCA) may also be necessary, depending on the severity of the event. The subsections below provide more information on the investigation process.

E.5.1 Engage with Technical Experts and Neutral Hydrogen Expert Panel

Technical experts on hydrogen safety and the affected system's design should be sought from the onset of the incident and throughout recovery to ensure that safety design features and practices are continuously applied. Technical expertise could also be needed to assist with hazard analysis and development of mitigation plans, inspection of the event scene, investigation of the incident and near-misses, and development of strategies to recover and return the organization back to safe operation.

E.5.2 Perform Internal Investigation

After any incident, an investigation **must** be performed to determine the underlying reason(s) for the incident. As illustrated in Figure 1, the following activities are involved in the execution of an incident investigation to support an RCA:

(1) Form an incident investigation team:

a. Include incident investigation experts from both within and outside the organization who have knowledge of the equipment or process that was associated with the incident.

b. The team should have a diverse background.

c. The type and level of incident will dictate the number and types of experts that will be required.

d. The team members should be assigned roles and tasks to perform during the investigation.

(2) Preserve, collect, document, and organize evidence:

a. During the investigation, continue to preserve the incident scene by taking photos, documenting missing equipment, recording operational data, and collecting any other necessary information. Gather as much information as possible immediately following an incident.

b. Collect data and evidence from as many sources as possible, including physical, positional, electrical forms, eyewitness testimonies, and first responders, among others.

Document the evidence collected in a consistent and organized form. Evidence will be referenced in the future; ensure the ability to quickly locate entries for future reference in the analysis process. Formal methods for performing investigations of a safety-related hydrogen event are identified in NFPA 921, *Guide for Fire and Explosion Investigations*;[5] the Center for Chemical Process Safety's *Guidelines for Investigating Process Safety Incidents*,[6] and DOE's *Accident Investigation Handbook*.[7] However, facility owners may implement their own methodology.

During the investigation, site owners and local/federal government hazmat organizations may be permitted onsite, but others may be restricted. Confidentiality and legal issues might also prevent involvement or delay a response. Fire marshal offices are often involved in high-visibility incidents, but they may not have the expertise to investigate hydrogen accidents.

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[5] National Fire Protection Association Standard 921, Guide for Fire and Explosion Investigations. Quincy, MA

[6] Guidelines for Investigating Process Safety Incidents, Center for Chemical Process Safety. May 2019

[7] DOE Handbook DOE-HDBK-1208-2012. Accident and Operation Safety Analysis, Volume 1: Accident Analysis Techniques and Volume II: Operational Safety Analysis Techniques. U. S. Department of Energy, Washington DC

The incident investigation team experts should make recommendations to address the root cause(s) and to prevent or mitigate future risks. Recommendations should be implementable by the organization. It is best practice if recommendations adhere to the inherently safety designconcepts of minimize, substitute, moderate, and simplify.[8]

The final activity is to complete and document the incident investigation. The investigation would be included in the final report (see Section E.7) and may be used as a future reference.

E.5.3 Perform Root Cause Analysis

The intent of an RCA is to investigate the conditions before and during the incident to determine the cause of the incident. The RCA could be performed in parallel with or independent of the formal investigation performed by the organization and insurance company. Similar to the formal investigation, the RCA also involves collecting data, analyzing data, assessing what failed within the system, and assessing the extent of the condition. The RCA tests the hypothesized failure and verifies that the results are consistent with the incident. Common tests could include computational models and event reconstruction.

The RCA is performed by trained individuals and may involve a third-party organization, depending on the extent of damage. Developing a communication protocol between the RCA team (internal or external) and the investigation team is important to ensure roles and responsibilities, such as handling of any new evidence, are outlined. Depending on the qualifications of the RCA team members, the RCA could also be used to validate investigation results.

E.5.4 Coordinate with Insurance Investigators

After filing a claim with the organization's insurance company, a formal investigation is performed by the insurance company and should be permitted without hinderance. Generally, these investigations are independent from the owner's/operator's investigation or RCA. The insurance company performs their due diligence of the events that have happened. Information required by the insurance company most likely can be obtained from the internal investigation and RCA reports.

E.6 Initiate Restoration Activities

A successful recovery entails the organization returning to a safer operating condition by presenting improvements to the organization's management to remove or mitigate the root cause(s) of the incident. The following subsections discuss the process to return the facility to safe operations.

[8] https://h2tools.org/bestpractices/inherently-safer-design-concepts

E.6.1 Replace Emergency Response Supplies

It is imperative that emergency supplies and materials used or depleted in response to the incident be replenished and restored to ensure readiness for possible future emergencies.

E.6.2 Perform Cleanup and Repair Activities

Prior to any cleanup or repair, it should be confirmed with the organization's insurer and legal counsel that any pending investigations are completed so that if an investigation requires physical evidence from the scene of the incident, it is not damaged or removed. Any evidence or investigation required to complete an RCA of the incident should also be completed before beginning the cleanup activities.

The cleanup activities could take weeks or months and require a separate cleanup team be established. The cleanup team would need to report progress to the recovery coordination team lead.

After access is permitted, conduct repairs. Installation of hydrogen equipment may necessitate specialized credentials or training. Replacement of equipment might take time and impact the timeline of reopening. The repair staff should account for such possibilities.

The repair staff should communicate progress and prioritization to the recovery coordination team for relaying to the public and stakeholders; be transparent.

E.6.3 Identify, Replace, and Test Safety Devices

Part of the recovery process is to identify and replace all safety equipment damaged as a result of the incident. Ensure replacement parts are designed for the specific application and intended use.

E.7 Document Final Reporting and Lessons Learned

It's very important for an organization and for the hydrogen industry that the results of investigations, RCAs, and corrective actions be documented. A final report detailing these items becomes part of an organization's technical memory and a key element in future safety planning and training of personnel. New information discovered from the incident response could result in changes to an organization's current response plan or strategy.

Understanding and implementing the general protocols of proper conduct of operations in a project will protect personnel and equipment at the highest level and ensure operational success. At a minimum, project activities should be conducted according to written procedures that have been properly reviewed by supervisory, safety, and operational personnel. Figure 1 provides examples of organizations that would benefit from communicating the results of the final report, such as a press briefing or press release or presenting or submitting the final report to local and federal agencies and the hydrogen expert panel. The industry would gain insights on common cause failures and/or recovery and response strategies.

E.8 Implement Corrective Actions

Depending on the results of the formal investigation and RCA, facility modifications and/or changes to the organization's processes/procedures may be required. These facility or process changes are usually tracked by the organization for completion and validation.

E.9 Perform Safety Startup Operations

The return to full capacity should be conducted in a safe and controlled manner. When an organization returns to a normal operating condition, they should confirm the facility/process is objectively safer. See Appendix D for an example of an operational readiness assessment.

E.10 Information Sharing

E.10.1 Neutral Third-Party Hydrogen Expert Panel

A neutral third-party hydrogen expert panel generally participates in the recovery of a hydrogen incident or event. Information provided to the hydrogen expert panel should be protected for confidentiality and integrity. Figure 1 illustrates instances where communication/interface with the hydrogen expert panel would be advantageous. Incidents evaluated by the U.S. Hydrogen Safety Panel are discussed in a database that can be found at the following link: *https://h2tools.org/lessons?search_api_fulltext=.*

E.10.2 Share Incident Reports and Lessons Learned with Community

Sharing information on the incident, response, recovery, and lessons learned with the hydrogen industry and potentially the public can be very valuable. New information discovered from the incident response could cause another organization to modify their current response plan or recovery strategy. Transparency in sharing of information not only can possibly prevent a similar incident but can also help build public trust in the organization and could lead to system design changes in the industry by other companies and/or codes/standard organizations to prevent similar accidents. Information sharing might be done during outreach sessions to the local community, including presentations of the incident and lessons learned on response and recovery.

Lessons learned from hydrogen incidents can also be obtained by incident reports that are publicly available or shared by the affected organization. The lessons learned from actual incidents provide valuable insights on design flaws, procedural weaknesses, potential human errors, and the extent of damage. Both the U.S. and European Hydrogen Safety Panels have collected and analyzed lessons learned from past incidents, which can respectively be accessed at https://h2tools.org/lessons and https://hysafe.info/hiad-2-0-free-access-to-the-renewed-hydrogen-incident-and-accident-database/ .

CENTER FOR Hydrogen SAFETY
Connecting a Global Community

The **Center for Hydrogen Safety** is a global non-profit dedicated to promoting hydrogen safety and best practices worldwide by:

- Supporting and promoting the safe handling and use of hydrogen across applications in the energy transition, and
- Providing a common communication platform with a global scope to ensure safety information, guidance, and expertise is available to all stakeholders...

As the number of producers and end-users of hydrogen grows, the Center for Hydrogen Safety is committed to providing resources to educate them on the safe handling of this critical energy carrier.

https://www.aiche.org/chs

AIChE

H2 HYDROGEN Safety Panel

The **Hydrogen Safety Panel** was formed in 2003 by the U.S. Department of Energy to help develop and implement practices and procedures that would ensure safety in the operation, handling, and use of hydrogen and hydrogen systems. The primary objective is to enable the safe and timely transition to hydrogen and fuel cell technologies. This is accomplished by:

- Providing expertise and recommendations and assisting with identifying safety-related technical data gaps, best practices, and lessons learned, and
- Ensuring that safety planning and safety practices are incorporated into hydrogen projects.

If you have an interest in utilizing the expertise of the Panel, contact the program manager by email at hsp@h2tools.org.

Pacific Northwest NATIONAL LABORATORY

U.S. DEPARTMENT OF ENERGY
Energy Efficiency & Renewable Energy