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The #H2IQ Hour

Today's Topic: Hydrogen Safety Panel

This presentation is part of the monthly H2IQ hour to highlight hydrogen and fuel cell research, development, and demonstration (RD&D) activities including projects funded by U.S. Department of Energy's Hydrogen and Fuel Cell Technologies Office (HFTO) within the Office of Energy Efficiency and Renewable Energy (EERE).

This webinar is being recorded and will be available on the [H2IQ webinar archives](#).

Technical Issues:

- If you experience technical issues, please check your audio settings under the “Audio” tab.
- If you continue experiencing issues, direct message the host, Kyle Hlavacek

Questions?

- There will be a Q&A session at the end of the presentation
- To submit a question, please type it into the Q&A box; **do not** add questions to the Chat

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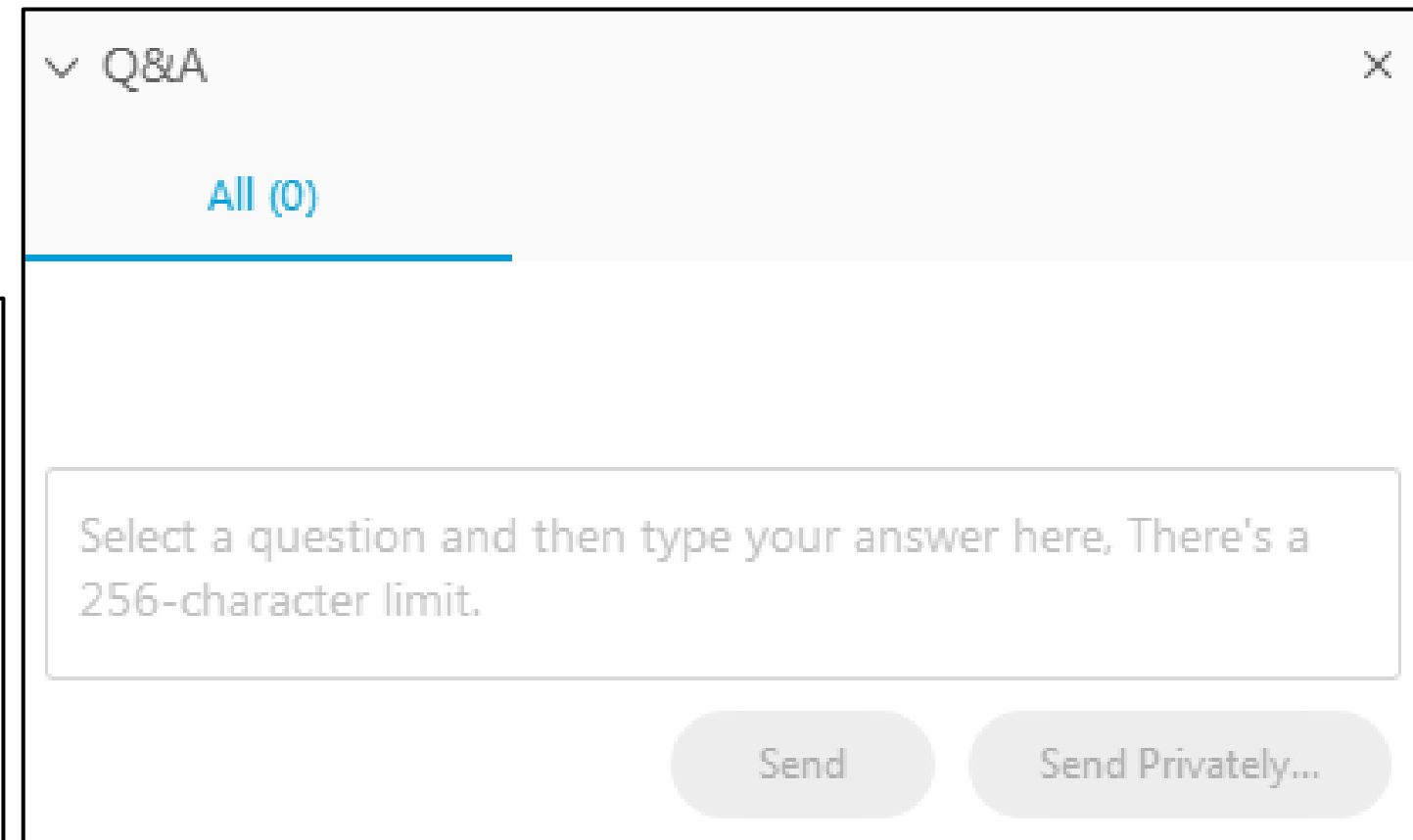
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The #H2IQ Hour Q&A

Please type your questions
into the Q&A Box

Open the Q&A panel

To open the Q&A panel, click Panel options (Windows)
or More options (Mac)  and select **Q&A**



The screenshot shows a web interface for a Q&A panel. At the top left, there is a dropdown menu with a downward arrow and the text "Q&A". To the right of this is a close button with an "x" icon. Below the dropdown, the text "All (0)" is displayed in blue. A horizontal blue line separates this header from the main content area. The main content area contains a text input field with the placeholder text "Select a question and then type your answer here, There's a 256-character limit." At the bottom right of the input field, there are two buttons: "Send" and "Send Privately...".



Hydrogen Safety Panel: 20 Years of Unparalleled Impact and What Comes Next

Nick Barilo

Hydrogen Safety Program Manager
Pacific Northwest National Laboratory

November 30, 2023



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Acknowledgements

U.S. Department of Energy Hydrogen and Fuel Cell Technologies Office (Sunita Satyapal, Director, Laura Hill, Safety, Codes, and Standards Manager, and Christine Watson)

AICHE staff supporting the AICHE-CHS CRADA

“The future of the safety movement is not so much dependent upon the invention of safety devices as on the improvement of methods of educating people to the ideal of caution and safety.”

— Walter Dill Scott

Why Focus on Hydrogen Safety

Safety issues can be a 'deal breaker' and must be addressed for successful hydrogen technology acceptance and deployment

Its Use as a Fuel is New to Many

- ▶ Users may lack experience or expertise for its safe use
- ▶ Some users have misconceptions... and may not know that they don't know



Stable Foundation

- ▶ Hydrogen can be used safely... It has been for nearly a century by industry
- ▶ Safety knowledge and best practices exist

Dangerous Assumptions

- ▶ “We already know how to use hydrogen safety” (apathy - established users)
- ▶ “Hydrogen is like any other flammable gas” (misconceptions - new players)
- ▶ “Hydrogen is too dangerous” (fear - general public/AHJs)

Failing to address the knowledge gaps can result in impactful incidents and industry setbacks

What do These Have in Common?



See: Hindenburg, Exploring the Truth by Addison Bain (2014)

Hollywood's Take on Hydrogen (Glass Onion)



No Worries... Incidents Won't Happen to Me

▶ Electrolyzer

- Personnel did not fully understand the interrelation of electrolyzer membrane gas permeability, membrane degradation, and dynamic operating range

▶ Hydrogen Vehicle Fueling Station

- Assembly error of an end plug for the high-pressure hydrogen tank

▶ Hydrogen Transport

- Incorrect pressure relief devices installed during maintenance

▶ Hydrogen Tanker Loading

- Unauthorized repair and failure to follow procedures

▶ Hydrogen Bus Fueling Station

- An incompatible pressure relief device was installed



Courtesy of Gangwon Fire HeadQuarter

Damage from Electrolyzer Incident

The Impact of Incidents



Union Carbide pesticide plant incident,
Bhopal, India, December 1984



Space Shuttle Challenger Explosion,
January 1986

Hydrogen Safety... Much to Consider



Connecting People to Safety Knowledge

- **Communication of hydrogen-specific safety guidance** will be critical to the success of hydrogen as a part of the global energy transition
- Establishing and communicating best safety practices **from a trusted, independent resource** is essential





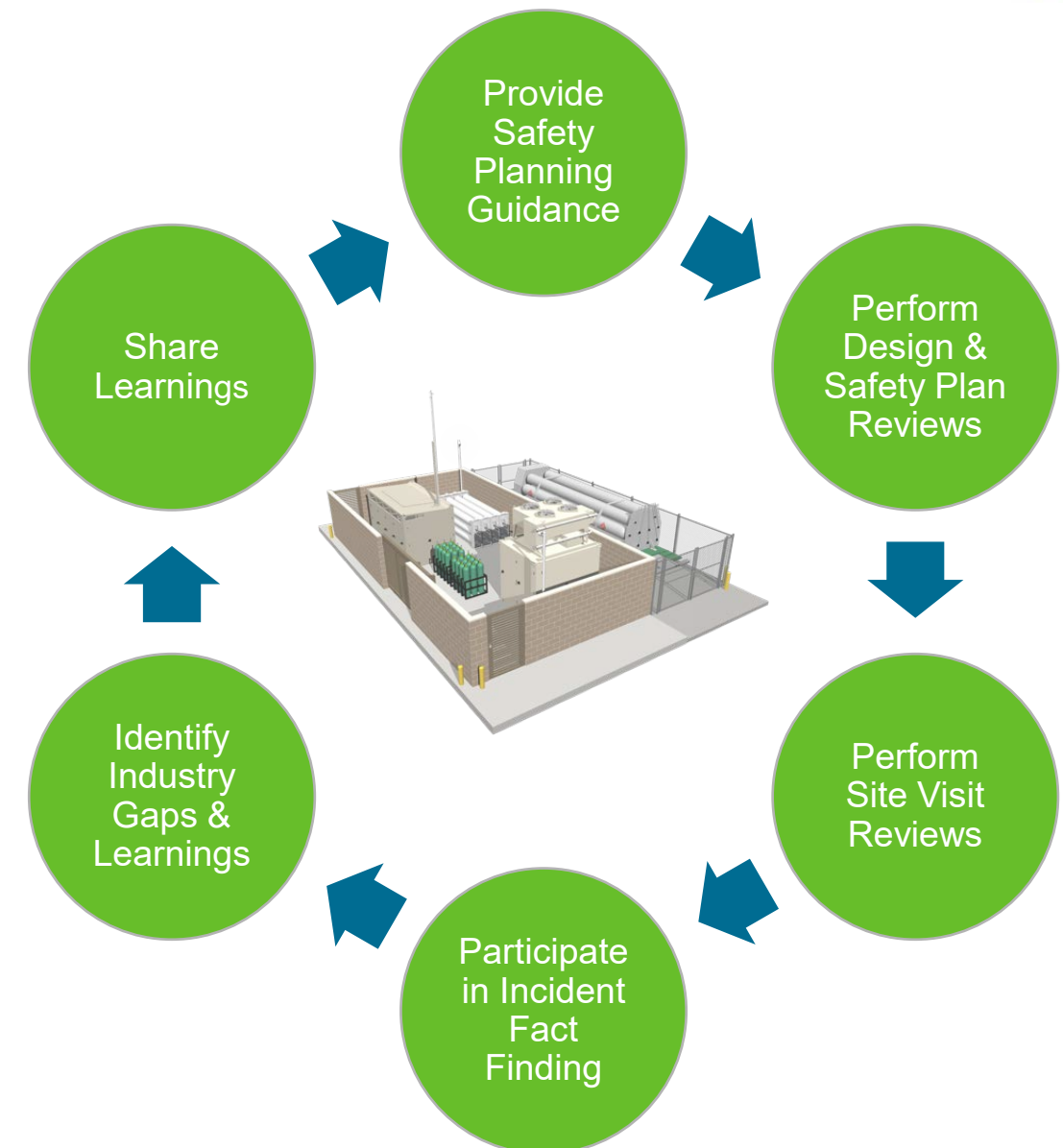
Hydrogen Safety Panel (HSP)

HSP Founding Purpose and Objective

Purpose: Share the benefits of extensive experience by providing suggestions and recommendations pertaining to the safe handling and use of hydrogen.

Objective: Enable the safe and timely transition to hydrogen technologies by:

- ▶ Participating in hydrogen projects to ensure safety is adequately considered
- ▶ Providing expertise and recommendations to stakeholders and assisting with identifying safety-related gaps, best practices, and lessons learned



Steve Weiner's Early HSP Vision



DOE and the Hydrogen Safety Panel are trying to achieve safe operation, handling, and use of hydrogen and hydrogen systems for all DOE projects. That vision will be achieved when

- **Safety-related technical data gaps are identified and addressed.**
- **Project teams are aware of relevant issues and best practices that affect the safe operation and handling of hydrogen and related systems.**
- **Project teams give sufficient priority to safety in their work.**



Hallmarks of Steve's philosophy

- *Engage stakeholders in all aspects of our hydrogen safety program*
- *Focus interactions with project teams on learning, knowledge sharing, and encouragement of thorough, continuous, and priority attention to safety...rather than as audit or regulatory exercises*

Steve Weiner was the founding manager of the Hydrogen Safety Panel and PNNL's Hydrogen Safety Program. He managed the activities from 2003-2012.

HSP Timeline



HSP Established

2003

2006

2009

2012

2015

2018

2021

2024

HSP Reviews

100

200

300

400

500

600

650



Safety Planning
Guidance Developed



Online Best Safety
Practices Published



HSP Support
of California H2
Infrastructure Started



HSP Mentoring
Program Started



HSP Begins
Supporting CHS



Meet the Current HSP



Nick Barilo
HSP Manager and Executive Director of the Center for Hydrogen Safety



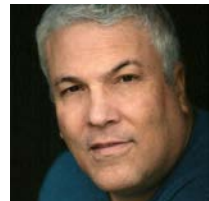
Tom Drube
Cryogenic Hydrogen Expert at Chart Industries



Chris LaFleur
Risk & Reliability Analyses Manager at Sandia National Laboratories



Ilse Alcantara Reyes
Test Engineer at NASA White Sands Test Facility



Rick Tedeschi
Chair of the HSP Project Management (retired)



Dave Farese
Durham Consulting Air Products (retired)



David Moore
Founder, President and CEO of the AcuTech Group



Brian Somerday
Materials Engineering Consultant with Somerday Consulting



Dr. Regis Bauwens
Senior Lead Research Scientist at FM Global



Donald Frikken
Internationally recognized authority in piping systems at Becht



Larry Moulthrop
Principal Engineer at H2@LMDesk



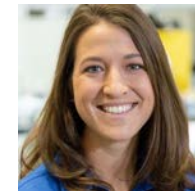
Gary Stottler
Director of Engineering for the Standard Hydrogen Corporation



Dr. Harold Beeson
Forensic Scientist at WHA International NASA (retired)



Livio Gambone
Head of Hydrogen Storage at Nikola Motor



Dani Murphy
Senior Mechanical and Forensic Engineer at WHA International Inc.



Kelly Thomas
Vice President & Blast Effects Section Manager at BakerRisk



Ken Boyce
Principal Engineer Director, Energy & Power Technologies at UL LLC



Aaron Harris
Technical Director of Hydrogen Energy at Air Liquide



Annmarie Purmer
Global Process Safety Manager at OCI Global



Tom Witte
CEO at Witte Engineered Gases & Cryogenics



Bud Bucci
Emergency Management and Fire Protection (retired)



Brian Ladds
Hazardous Materials Coordinator for the Calgary Fire Department in Alberta, Canada



Spencer Quong
Vice President and Chief Technical Officer of Quong & Associates

A Safety Partnership



In 2018 PNNL partnered with the American Institute of Chemical Engineers (AIChE) to establish a Center for Hydrogen Safety (CHS). CHS expands access to the HSP by:

- ▶ **Making the HSP more readily available to industry and government agencies in the US and internationally**
- ▶ **Enabling less cumbersome/time-consuming multi-organization collaboration**

PNNL transferred its first responder hydrogen safety training resources to AIChE to enable broader access to online and in-person training resources



**Pacific
Northwest**
NATIONAL LABORATORY



HSP Impact



Unparalleled Impact



- Expert Safety Advice for Hydrogen Projects
- Identifying & Addressing Industry Safety Gaps
- Knowledge Generation and Dissemination
 - Best Safety Practices
 - eLearning Courses
 - Educational Webinars
 - Other CHS Activities
- Incident Fact-finding and Lessons Learned

Unparalleled Impact

- **Expert Safety Advice for Hydrogen Projects**

- Identifying & Addressing Industry Safety Gaps

- Knowledge Generation and Dissemination

- Best Safety Practices
- eLearning Courses
- Educational Webinars
- Other CHS Activities

- Incident Fact-finding and Lessons Learned

620 Reviews **444** Projects

HSP Value

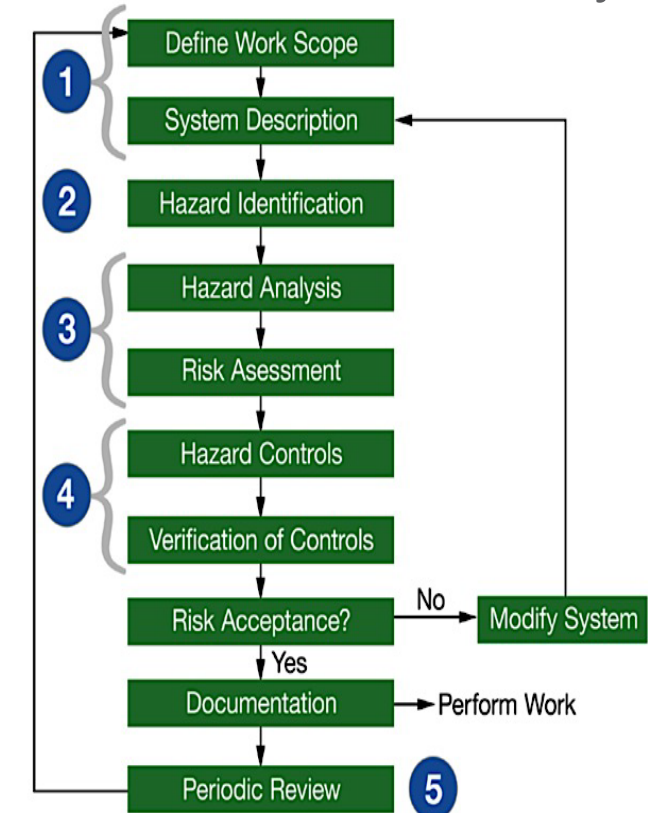
- ▶ Non-regulatory, objective, and neutral
- ▶ Helps reduce costs
 - Costs from over-engineering
 - Delayed approvals
 - Missed safety considerations/features
- ▶ Provides a balanced solution to questions and problems
- ▶ Helps projects avoid safety incidents
- ▶ Helps establish stakeholder and public confidence



Typical HSP Activities:

- ▶ Design and document reviews
- ▶ Hazard analysis participation/review
- ▶ Site safety evaluations
- ▶ Safety training and webinars
- ▶ Outreach
- ▶ Incident investigation

HAZOP/Risk Analysis



Unparalleled Impact

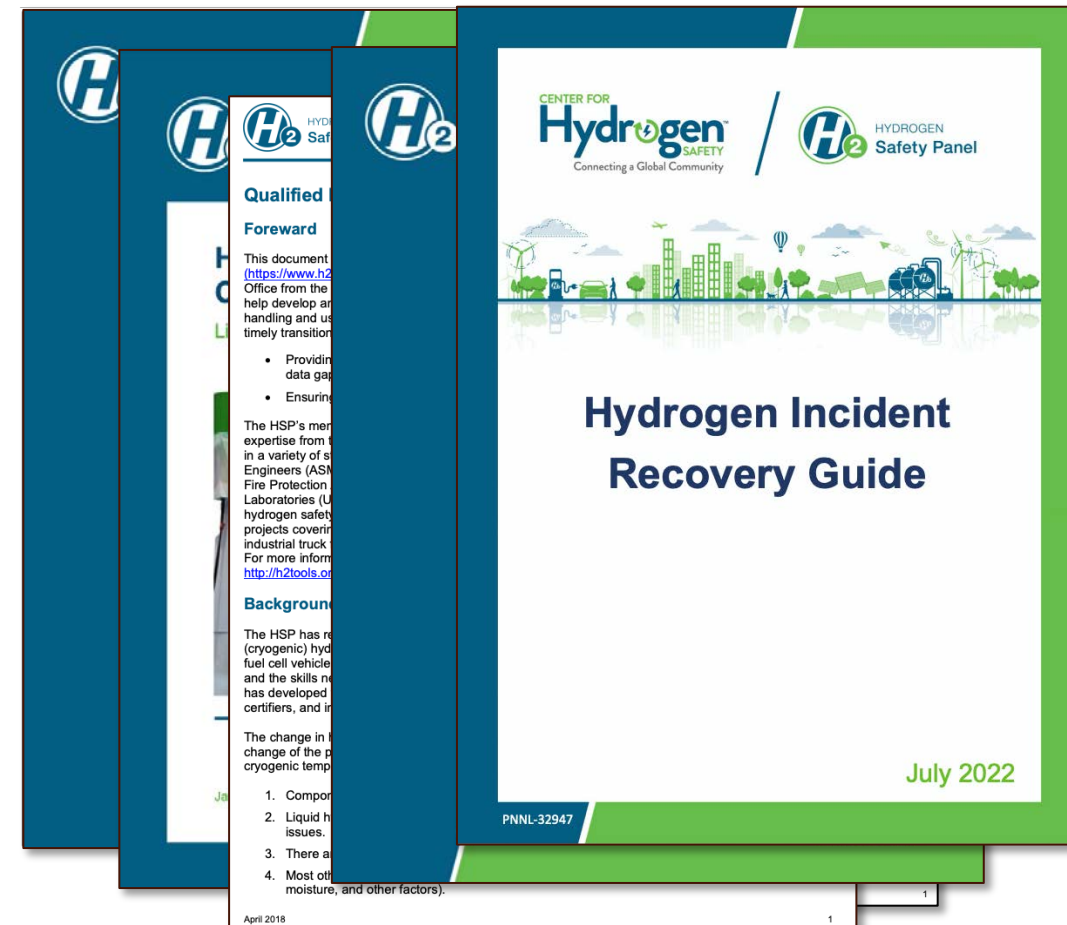


- Expert Safety Advice for Hydrogen Projects
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29 Panel Meetings

15 White Papers and Guides

White Papers



Unparalleled Impact



- Expert Safety Advice for Hydrogen Projects
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100 Best Safety Practices

120,000 Pageviews per Year

- ▶ **Introduction to Hydrogen**
 - So, you want to know something about hydrogen?
- ▶ **Hydrogen Properties**
 - Hydrogen compared with other fuels
- ▶ **Safety Practices**
 - Safety culture
 - Safety planning
 - Incident procedures
 - Communications
- ▶ **Design and Operations**
 - Facility design considerations
 - Storage and piping
 - Operating procedures
 - Equipment maintenance
 - Laboratory safety
 - Indoor refueling of forklifts

Unparalleled Impact



- Expert Safety Advice for Hydrogen Projects
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10 eLearning Courses
11,200 Students



103
Credentials Earned

Fundamental Hydrogen Safety eLearning Courses

- Hydrogen as an Energy Carrier
- Properties and Hazards
- Safety Planning
- Facility Design
- Equipment and Components
- Liquid Systems
- Material Compatibility
- System Operation
- Inspection & Maintenance
- Hydrogen Laboratory Safety

Unparalleled Impact



- Expert Safety Advice for Hydrogen Projects
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9 Webinars

3,500 Attendees

- ▶ Safety of Water Electrolysis
- ▶ Global Hydrogen Safety Codes and Standards
- ▶ Ventilation Considerations for Hydrogen Safety
- ▶ Material Compatibility Considerations for Hydrogen
- ▶ Overview of Hazard Analysis for Hydrogen Applications
- ▶ Safety for the Transportation and Delivery of Hydrogen
- ▶ Liquid Hydrogen: Safety and Design Considerations
- ▶ Gaseous Hydrogen: Safety Considerations
- ▶ Hydrogen Laboratories: Safety Considerations

Unparalleled Impact



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23 HSP Members

Collaborating with **110+** CHS Member Orgs

Helping CHS to address crucial safety topics and make a significant impact.

Sharing Safety Knowledge

- ▶ Member Meetings
- ▶ Incident Response Meetings
- ▶ Member Safety Questions

Working Groups

- ▶ Hydrogen Blending with Natural Gas
- ▶ Hydrogen Equipment and Component Failure Rates
- ▶ Safety Culture
- ▶ Public Information on Hydrogen



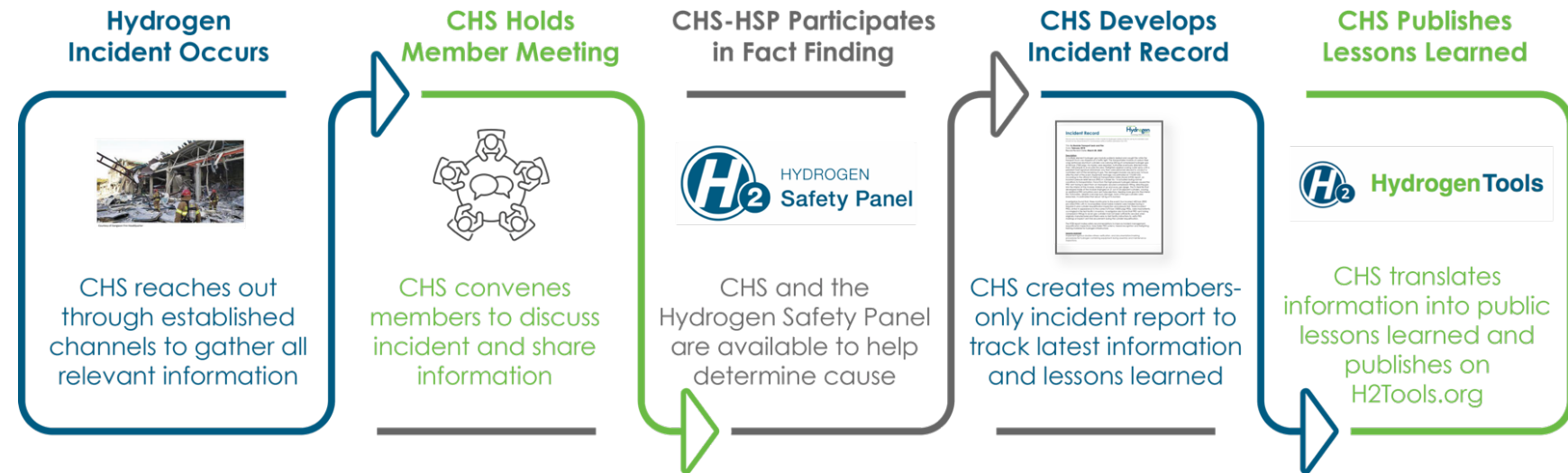
Unparalleled Impact

- Expert Safety Advice for Hydrogen Projects
- Identifying & Addressing Industry Safety Gaps
- Knowledge Generation and Dissemination
- **Incident Fact-finding and Lessons Learned**

The HSP's incident fact-finding activities will inform the development and improvement of other resources:

- ▶ Education Materials: new courses, revised course content, etc.
- ▶ Technical Bulletins
- ▶ Working Groups: to address important safety issues and develop learnings for the CHS community and industry
- ▶ Conferences and workshops to broadly share incident information and learnings

222 Public Lessons Learned
83,000 Pageviews per year
19 CHS Early Records



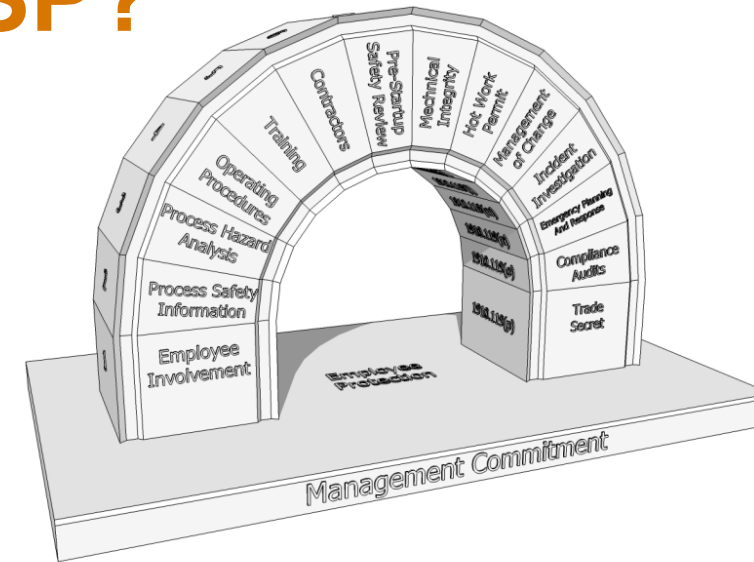
The HSP's dedicated incident fact-finding activities :

- ▶ Pursue connecting with the incident organization and identifying what happened
- ▶ **Meet with CHS membership to discuss what is known and answer fundamental hydrogen safety questions**
- ▶ Develop a CHS incident record and update the record as new information is identified
- ▶ Finalize the record for the H2Tools Lesson Learned database/public record

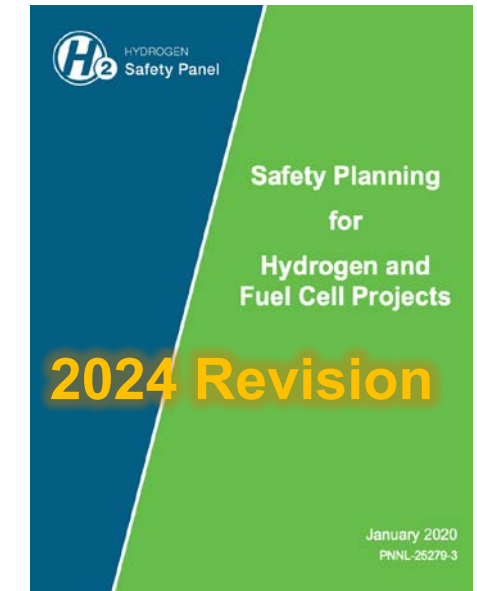
What's Next for the HSP?



- Encouraging process safety management (PSM) concepts in safety planning
- Delayed ignition events white paper
- Electrolyzer and fueling station safety eLearning courses
- Venting system design considerations webinar
- Hydrogen safety training at the CHS conference
- New best safety practices for blending hydrogen with natural gas
- Starting an HSP mentoring program



- Learn from other PSM industries
- Maintain the highest level of safety performance
- Focus on a hydrogen safety management system framework
 - Risk analysis
 - Strict control of hazard
 - Diligence
 - Continual improvement
 - Assurance to requirement



What's Next for the HSP?



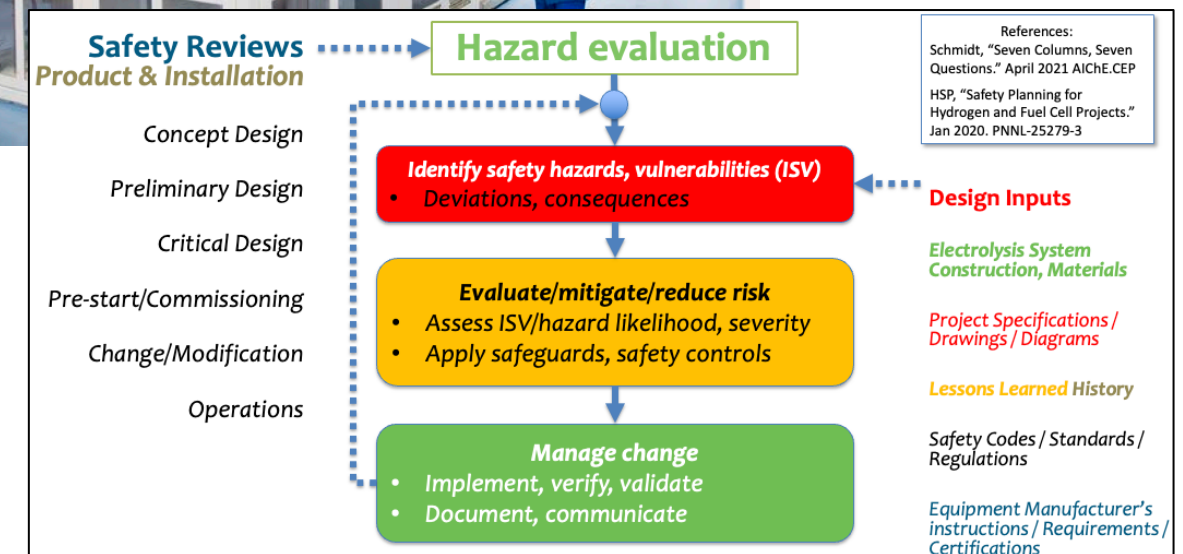
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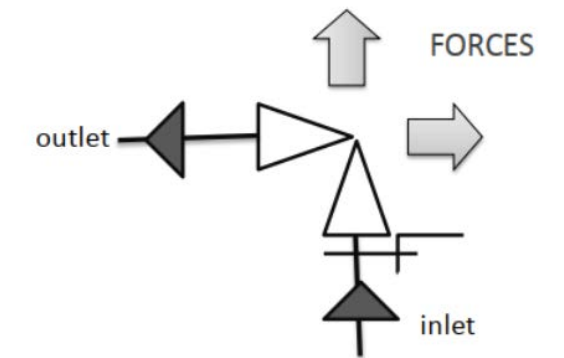
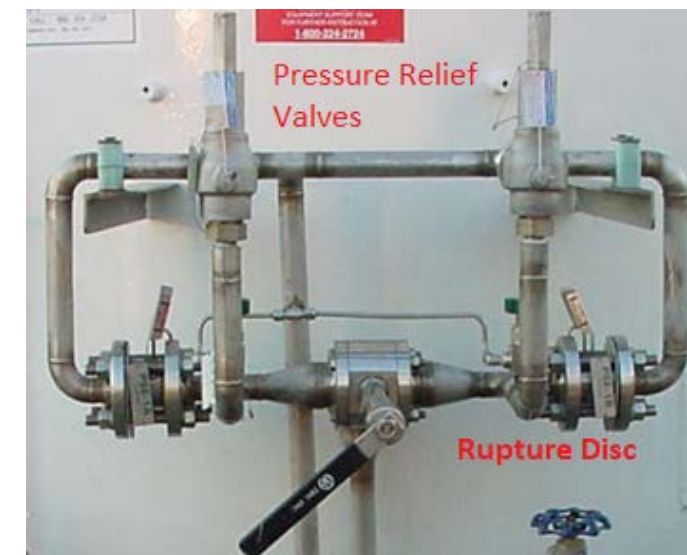


Figure 1: Reaction forces from discharge of gas



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CHS 2024 Americas Conference

May 20-23 in Las Vegas, NV



HSP Members Will Be Teaching Two Courses

- Fundamentals of Gaseous Hydrogen Safety
- Vent System Designs

What's Next for the HSP?

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Develop New Best Safety Practices

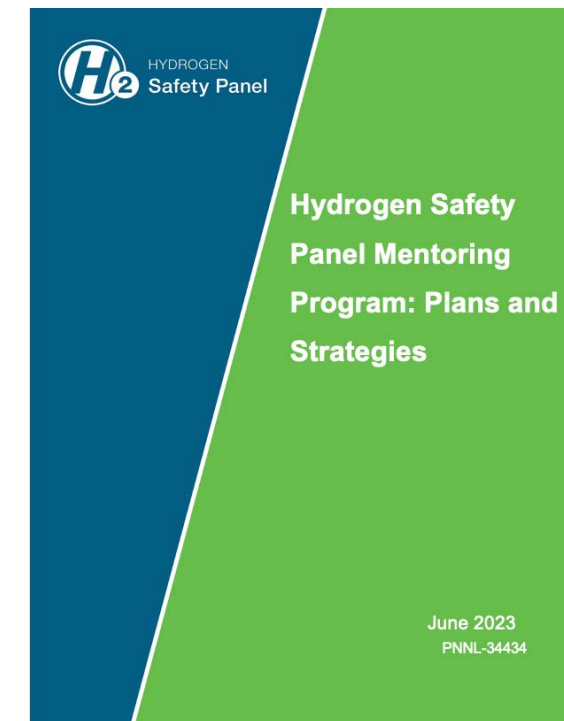


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- **Starting an HSP mentoring program**

- Ensure stability of the HSP's resources to meet the needs
- Grow the industry's expertise in hydrogen safety



How to Access HSP Services



HSP service request form: <https://h2tools.org/form/request-for-hydrogen-safety-pane>

	DOE HFTO and Some CEC* Funded Projects	Other Projects
Safety Plan Review	Send the plan to hsp@h2tools.org	Submit service request
Document/Design Review	Submit service request	Submit service request
HAZOP Participation or Review	Submit service request	Submit service request
Other reviews	Submit service request	Submit service request
Contract for work needed	No	Yes**
Client funding needed	No	Yes
Time needed for contract disposition	N/A	1-2 weeks
Review time	6-8 weeks	6-8 weeks
Time to process an NDA with the HSP, if one is needed	4 weeks	4 weeks

* Check with the CEC or contact us direct to determine if Client funding is needed.

**A signed AIChE/CHS contract and a deposit are needed to initiate the review activity. Client contracts and substantial revisions of the AIChE contract cannot be accommodated.

HSP Service Request Form

Requesting Organization

Contact Name

Position

Phone

Email

Project Title

Scope/Summary of Project:

Select HSP services requested and specify the expected need by date for each. Some reviews and associated reports may take 6-8 weeks to complete.

Service Requested	Need By Date
<input type="checkbox"/> Safety Plan Review	<input type="text" value="mm/dd/yyyy"/>
<input type="checkbox"/> Preliminary Design/Information Review	<input type="text" value="mm/dd/yyyy"/>
<input type="checkbox"/> 30% Design Review	<input type="text" value="mm/dd/yyyy"/>

Our Legacy of Impact... Continues

Dispelling incorrect assumptions

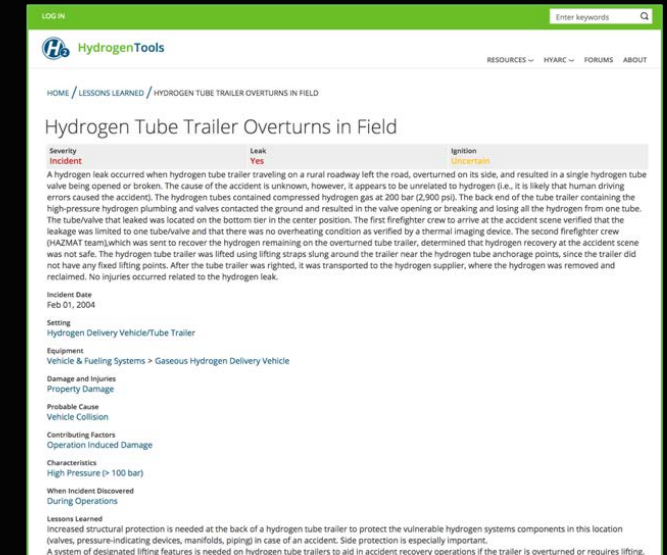


Helping projects work safely



620 Reviews **444** Projects

Building safety resources



100 Best Safety Practices
120K Pageviews per Year

How Can We Help You?

How to Connect with Me or the HSP



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