Safety Planning Guidance

for

Hydrogen and Fuel Cell Projects

April 2010

U.S. Department of Energy
Fuel Cell Technologies Program

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Safety Planning Guidance for Hydrogen and Fuel Cell Projects

A. Introduction

This guidance document provides applicants and recipients with information on safety requirements for hydrogen and fuel cell projects funded by the U. S. Department of Energy (DOE) Fuel Cell Technologies Program.

Safe practices in the production, storage, distribution, and use of hydrogen are essential for the widespread acceptance of hydrogen and fuel cell technologies. A catastrophic failure in any project could damage the public's perception of hydrogen and fuel cells. The project safety plan is meant to help identify and avoid potential hydrogen and related incidents. This guidance document aims to assist recipients in generating their safety plan, which will serve as a guide for the safe conduct of all project work.

In general, a good safety plan identifies immediate (primary) failure modes as well as secondary failure modes that may come about as a result of other failures. In effective safety planning, every conceivable failure is identified, from catastrophic failures to benign collateral failures. Identification and discussion of perceived benign failures may lead to the identification of more serious failures.

Potential hazards in any work, process or system should always be identified, analyzed and eliminated or mitigated as part of sound safety planning. Other safety aspects that may be adversely affected by a failure should be considered. These aspects include threats or impacts to:

- **Personnel.** Any hazards that pose a risk of injury or loss of life to personnel and the public at-large must be identified and eliminated or mitigated. A complete safety assessment considers not only those personnel who are directly involved in the work, but also others who are at risk due to these hazards.
- **Equipment.** Damage to or loss of equipment or facilities must be prevented or minimized. Damage to equipment can be both the cause of incidents and the result of incidents. An equipment failure can result in collateral damage to nearby equipment and property, which can trigger additional equipment failures or even present additional risks. Effective safety planning considers and minimizes serious risk of equipment and property damage.
- **Business Interruption.** The prevention of business interruption is important for commercial entities. Hazardous events may lead to interruption in providing service or product. A complete safety plan in these instances would also include a contingency plan for providing needed services or manufacturing.
- **Environment.** Damage to the environment must be prevented. Any aspect of a natural or built environment that can be harmed due to a failure should be identified and analyzed. A qualification of the failure modes resulting in environmental damage must be considered.

B. Requirements and Procedures

All projects funded by the DOE Fuel Cell Technologies Program will be required to submit a project safety plan with the exception of those projects relating to non-experimental computational or analytical work. Safety plans will be required to cover the work of the award recipient and any subcontractors. This guidance document, in addition to any example project safety plans provided by the DOE project officer, should provide sufficient background for preparing the safety plan. However, the responsibility of selecting and using a specific safety methodology falls upon the applicant or principal investigator and collaborating groups. A variety of practices exist for the identification and analysis of safety hazards and the team can choose an approach that is best suited for their project.

DOE will identify specific safety plan deliverable requirements at the time of award; the specific instructions will be stated on the "Federal Assistance Reporting Checklist" (Form DOE F 4600.2) within the award package. The specific procedure for each project may differ. Generally, though, the draft project safety plan will be required 90 days after the award has been signed. The safety plan should not contain any proprietary or confidential information since it will be reviewed by a panel external to DOE. Once submitted, the plan will be reviewed and specific comments and feedback will be provided to the recipient. In some cases, the recipient will then be required to address all necessary comments and submit a revised safety plan. For any project involving multiple phases, the updating and resubmitting of the safety plan may also be required.

A preliminary safety plan may be required during the submission of the application package as part of the Funding Opportunity Announcement (FOA) issued by DOE. If a preliminary safety plan is required, the FOA will provide further direction regarding specific requirements.

All project safety plan submissions and questions should be sent via e-mail to the project officer identified in Block 11 of the Notice of Financial Assistance Award.

C. The Safety Plan

A project safety plan addresses potential threats and impacts to personnel, equipment and the environment. As an integral part of any project, a safety plan should reflect that sound and thoughtful consideration is given to the identification and analysis of safety vulnerabilities, prevention of hazards, mitigation of risks and effective communications. Safety plans should be "living documents" that recognize the type of work being conducted, the factors of human error, the nature of equipment life and the inevitable changes that occur over the project life.

A project safety plan should be prepared using a graded approach based on level of risk and project complexity. The plan should cover all experimental/operational work being conducted with particular emphasis on the aspects involving hydrogen, hazardous materials handling and fuel cell systems. The elements of a good safety plan are described in Appendix IV and summarized as follows:

1. Scope of Work
2. Organizational Safety Information

- Organizational Policies and Procedures
- Hydrogen and Fuel Cell Experience

3. Project Safety
   - Identification of Safety Vulnerabilities (ISV)
   - Risk Reduction Plan
   - Operating Procedures
     - Operating steps
     - Sample handling and transport
   - Equipment and Mechanical Integrity
   - Management of Change Procedures
   - Project Safety Documentation
4. Communication Plan
   - Employee Training
   - Safety Reviews
   - Safety Events and Lessons Learned
   - Emergency Response
   - Self-Audits
5. Safety Plan Approval
6. Other Comments or Concerns

Each element is briefly described in the following sections. The text boxes included in the following sections provide useful background information on good safety practices and should be thoughtfully considered in preparing your safety plan. Detailed documentation related to this background information does not need to be included in the safety plan itself. Project teams may also find H_2 Safety Best Practices (http://h2bestpractices.org) to be a useful reference for safety planning. This website captures the experience that already exists in a wide variety of industrial, aerospace and laboratory settings with topics covering safety practices, design and operations. An extensive reference list is also supplemented with lessons learned from incidents and near-misses.

1. Scope of Work. The plan should briefly describe the specific nature of the work being performed to set the context for the safety plan. It should distinguish between laboratory-scale research, bench-scale testing, engineering development, and prototype operation. All intended project phases should be described. In describing the work, it is valuable to quantify the amounts of hazardous materials generated, used and stored. Even laboratory-scale experiments may result in substantial risks when a quantity of hydrogen or other hazardous material is stored in or near the laboratory.

The plan should discuss the location of activities (description of facilities, types of personnel, other operations/testing performed at the facility, adjacent facilities) and describe how the activities will be coordinated across the total project. **Safety plans should cover the work of any subcontractors.** Any relevant permits that apply to current and planned operations should be listed.

2. Organizational Safety Information

Organizational Policies and Procedures. The plan should describe how the safety policies and procedures of the organization are implemented down to the project and staff member levels for the work being performed. Staff member involvement is important in the development and implementation of comprehensive project safety plans.

Hydrogen and Fuel Cell Experience. Knowledge gained over a period of time can be an important asset in effective safety planning. The plan should describe the types of previous operations, degree of experience of project personnel, and how previous organizational experience with hydrogen and fuel cells will be applied to the project.

3. Project Safety

Identification of Safety Vulnerabilities (ISV). Assessment of the potential hazards associated with work at any scale from laboratory to operations begins with the identification of an appropriate assessment technique. The ISV is the formal means by which potential safety issues associated with laboratory or process steps, materials, equipment, operations, facilities and personnel are identified. The plan should describe:

- The ISV method that is used for this project
- Who leads and stewards the use and results of the ISV process
- Significant accident scenarios identified (e.g. higher consequence, higher frequency)
- Significant vulnerabilities (risks) identified
- Safety critical equipment

Hazardous Materials. The plan should discuss the storage and handling of hazardous materials and related topics including possible ignition sources, explosion hazards, material interactions, possible leakage and accumulation, and detection. For hydrogen handling systems, the plan should describe the source and supply, storage and distribution systems including volumes, pressures and with estimated use rates.

Two other questions should be addressed in the ISV:

- What hazard associated with this project is most likely to occur?
- What hazard associated with this project has the potential to result in the worst consequence?

The plan should describe how the ISV will be updated as new information becomes available. Typical ISV methods are described in Appendix I.

Risk Reduction Plan. The purpose of a risk reduction plan is to reduce or eliminate significant risks. The plan should describe prevention and mitigation measures for the significant safety vulnerabilities previously identified. The development of prevention and mitigation measures is usually done in conjunction with the ISV which assesses the scenarios and identified hazards. Risk binning is one available analysis tool used to classify vulnerabilities, as shown in Appendix II.

Operating Procedures

Operating Steps. The plan should list existing and planned procedures that describe the operating steps for the system, apparatus, equipment, etc. It should also reference specific safe work practices used to control hazards during operations such as lockout; confined space entry; opening equipment or piping; and control over entrance into a facility by maintenance, contractor, laboratory, or other support personnel.

> *Background Information: Procedures should be developed for each process or laboratory-scale experiment with the active involvement of project personnel. These written procedures should provide clear instructions for conducting processes or experiments in a safe manner. The procedures should include:*
> - *Steps for each operating phase, such as startup, normal operation, normal shutdown, emergency shutdown*
> - *Operating limits*
> - *Safety considerations, such as precautions necessary to prevent exposure and measures to be taken if physical contact or airborne exposure occurs*
> - *Safety systems and their functions*
>
> *Operating procedures should be updated promptly to reflect changes to chemicals and other materials, equipment, technologies and facilities*

Sample handling and transport. The plan should discuss any anticipated transport of samples and materials and identify the relevant policies and procedures that are in place to ensure their proper handling.

Equipment and Mechanical Integrity. The plan should describe how the integrity of equipment, piping, tubing, and other devices associated with the hazardous material handling systems will be assured.

> *Background Information: Mechanical integrity generally involves*
> - *Written procedures*
> - *Proper design, testing and commissioning*
> - *Validation of materials compatibility*
> - *Preventative maintenance plan*
> - *Calibration for safety related devices – The frequency should be consistent with applicable manufacturers' recommendations, adjusted as indicated by operating experience.*
> - *Testing and inspection – The types and frequency of inspections and*

tests should be consistent with applicable manufacturers' recommendations, adjusted as indicated by operating experience.
- *Training for maintenance, calibration, testing and inspection personnel.*
- *Documentation – Each calibration, inspection and test should be recorded. Typical records include date, name of the person, identifier of the device, description of what was done, and results. Any deficiencies outside acceptable limits should be highlighted.*
- *Correcting deficiencies that are outside acceptable limits*

Management of Change Procedures. The plan should describe the method that will be used to review proposed changes to materials, technology, equipment, procedures, personnel and facility operation for their effect on safety vulnerabilities.

<u>Background Information</u>:[1] *For changes resulting in a change to the safety information such as to the ISV or an operating procedure, the applicable safety information should be updated accordingly. Employees whose job tasks will be affected by the change must be informed of the change and retrained prior to resumption of work.*

Scale-up of the process, modification of equipment and changes in materials are commonly encountered and should be considered as changes that may result in the need to update the safety plan. Change may also refer to new personnel involved in the work, necessitating training.

Project Safety Documentation. The plan should describe how safety documentation is maintained for the project, including who is responsible, where documents are kept, and how it is accessed by project personnel.

<u>Background Information</u>: *Safety documentation includes*
- *Information pertaining to the technology of the project*
  - *A block flow diagram or simplified process flow diagram*
  - *Process chemistry*
  - *Maximum intended inventory of materials*
  - *Safe upper and lower limits for such items as temperatures, pressures, flows and concentrations*
  - *An evaluation of the consequences of deviations, including those affecting the safety and health of employees*
- *Information pertaining to the equipment or apparatus*
  - *Materials of construction*
  - *Electrical classification*
  - *Pressure relief system design and design basis*
  - *Ventilation system design*

[1] *Management of Change*, U.S. Chemical Safety and Hazard Investigation Board, Safety Bulletin No. 2001-04-SB, August 2001.

- *Design codes and standards employed*
- *Material and energy balances*

  - *Safety systems (e.g. alarms, interlocks, detection or suppression systems)*
  - *Safety review documentation, including the ISV*
  - *Operating procedures (including response to deviation during operation)*
  - *Material Safety Data Sheets*
  - *References such as handbooks and standards*

Safety documentation should be updated regularly to reflect changes to chemicals/other materials and their quantities, equipment, technologies, and facilities.

4. Communications Plan. The plan should describe how project safety information is communicated and made available to all project participants, including external partners.

Employee Training. The plan should describe formal programs and planned hazard-specific training related to the various hazards associated with the project. It should describe how the organization stewards training participation and verifies understanding.

<u>Background Information</u>: *It is crucial to provide hydrogen and other safety training for all project personnel responsible for handling equipment and systems containing hazardous materials. The training program should include*

- *Initial training that includes an overview of the process, a thorough understanding of the operating procedures, an emphasis on the specific safety and health hazards, emergency operations including shutdown, and safe work practices applicable to the employee's job tasks.*
- *Refresher training that is provided to each employee involved in operating a process to assure that the employee understands and adheres to the current standard operating procedures.*
- *Training documentation that shows each employee involved in operating a process has received and understood the training.*
- *For people maintaining process equipment, performing calibrations, etc., training needs to ensure that the employee can perform the job tasks in a safe manner.*

Safety Reviews. The plan should describe safety reviews that will be conducted for the project during the design, development and operational phases. The involvement and responsibilities of individual project staff in such reviews and how the reviews will be documented should be included. The ISV is expected to be one of the safety reviews performed for the project. Other safety reviews may be needed during the life of the project, including those required by organizational policies and procedures.

Safety Events and Lessons Learned. The plan should describe how safety events (incidents and near-misses) will be handled by the project team. The description should include:

- The reporting procedure within the organization and to DOE
- The method and procedure used to investigate events
- How corrective measures will be implemented
- How lessons learned from incidents and near-misses are documented and disseminated

By learning about the likelihood, severity, causal factors, setting and relevant circumstances regarding safety events, project teams are better equipped to prevent similar, perhaps more serious, events in the future. To be effective, this process requires a good investigation, a good report, and a great deal of information sharing as openly and thoroughly as possible.

An **INCIDENT** is an event that results in:

- a lost-time accident and/or injury to personnel
- damage to project equipment, facilities or property
- impact to the public or environment
- an emergency response or should have resulted in an emergency response

A **NEAR-MISS** is an event that, under slightly different circumstances, could have become an incident. Examples include:

- any unintentional hydrogen release that ignites, or is sufficient to sustain a flame if ignited, and does not fit the definition for an incident
- any hydrogen release which accumulates above 25% of the lower flammability limits within an enclosed space and does not fit the definition of an incident

Note that the definitions do not include all possible events that should be reported. The definitions are indicative of events that should be reported. All incidents and near-misses must be reported to the appropriate DOE project officer as soon as possible after the safety event has occurred. For DOE national laboratory-led projects, all incidents and near-misses should be reported to the appropriate DOE technology development manager as soon as possible after the safety event has occurred.

Background Information: The investigation of an incident should be initiated as promptly as possible. An event investigation team should consist of at least one member who is independent from the project team, at least one person knowledgeable in the process chemistry and actual operation of the equipment and process, and other persons with the right knowledge and experience to thoroughly investigate and analyze the incident. The event report should include:

- *Date of incident*
- *Date investigation began*
- *A description of the incident*
- *The factors that contributed to the incident*

- *Lessons learned from the incident*
- *Any recommendations resulting from the investigation*

The project team should promptly address and resolve the incident report findings and recommendations. Resolutions and corrective actions should be documented. The report should be reviewed with all affected personnel whose job tasks are relevant to the incident findings.

Hydrogen Incident Reporting and Lessons Learned (*www.h2incidents.org**), is a database which provides a voluntary mechanism for anyone to report an incident or near-miss and to benefit from the lessons learned from other reported incidents. All identifying information, including names of individuals, companies, organizations, vendors of equipment and locations are removed to ensure confidentiality and to encourage the unconstrained future reporting of events as they occur.*

Emergency Response. The plan should describe the emergency response procedures that are in place, including communication and interaction with neighboring occupancies and local emergency response officials.

Self-Audits. The plan should describe how the project team will verify that safety-related procedures and practices are being followed throughout the life of the project.

Background Information: Verification is usually accomplished via a compliance audit that is conducted by at least one person knowledgeable in the process who is external to the project. A report of the findings of the audit should be developed. The project team should promptly determine and document an appropriate response to each of the findings of the compliance audit with an appropriate action plan.

5. Safety Plan Approval. The review and approval process used for the project safety plan must be documented. It should be consistent with the organization's policies, and can be done by briefly describing the approval process used and/or completing an approval form. An example approval form is shown in Appendix III. In most cases, this approval process will include a review by the next management level and approved by the organization's safety representative.

6. Other Comments or Concerns. If appropriate, provide information on any topics not covered above, and any issues that may require assistance from DOE. Appendix IV – Safety Plan Checklist is also provided for use as a resource in preparing safety plans.

Appendix I – Acceptable ISV Methods

Background Information: Identification of Safety Vulnerabilities (ISV) can be done using any of several established industry methods. The ISV should be done at the project's earliest stages. The ISV helps the project team identify potential safety issues, discover ways to lower the probability of an occurrence, and minimize the associated consequences.

The ISV should address:

- The potential hazards of the operation
- Previous incidents and near misses
- Engineering and administrative controls applicable to the hazards and their interrelationships, e.g. the use of hydrogen detectors and emergency shutdown capability
- Mechanisms and consequences of failure of engineering and administrative controls
- A qualitative evaluation of a range of the possible safety and health effects resulting from failure of controls
- Facility location

The ISV should be performed by a team with sufficient expertise in all aspects of the work to be performed. At least one team member should have experience and knowledge specific to the set of processes, equipment and facilities being evaluated. Also, one member of the team needs to be knowledgeable in the specific ISV method being used.

Method	Description	References
FMEA Failure Modes and Effects Analysis	The FMEA process has these elements o Identify top level hazards and events o Identify related equipment, components, and processes o Identify potential failure modes and effects o Identify designs that provide inherent safety o Identify potential prevention and mitigation corrective action	o **http://www.fmeainfocentre.com/** a non-commercial web-based inventory dedicated to the promotion of FMEA o Government documents, including MIL-STD-882C and MILSTD-1629A o NASA Scientific and Technical Information **http://www.sti.nasa.gov/** o A discussion and worked example can be found in *Guidelines for Hazard Evaluation Procedures*, *Second Edition with Worked Examples*, Center for Chemical Process Safety, American Institute of Chemical Engineers, 1992.
"What If" Analysis	A speculative process where questions of the form "What if … (hardware, software, instrumentation, or operators) (fail, breach, break, lose functionality, reverse, etc.)..?" are formulated and reviewed.	A discussion and worked example can be found in *Guidelines for Hazard Evaluation Procedures*, *Second Edition with Worked Examples*, Center for Chemical Process Safety, American Institute of Chemical Engineers, 1992.
HAZOP Hazard and Operability Analysis	Systematically evaluates the impact of deviations using project information. Method was developed to identify both hazards and operability problems at chemical process plants.	An extensive description and worked example of the HAZOP procedure can be found in *Guidelines for Hazard Evaluation Procedures*, *Second Edition with Worked Examples*, Center for Chemical Process Safety, American Institute of Chemical Engineers, 1992.

Method	Description	References
Checklist Analysis	Method evaluates the project against existing guidelines using a series of checklists. This technique is most often used to evaluate a specific design, equipment or process for which an organization has a significant amount of experience.	o A discussion and worked example can be found in *Guidelines for Hazard Evaluation Procedures*, *Second Edition with Worked Examples,* Center for Chemical Process Safety, American Institute of Chemical Engineers, 1992. o Risk-based decision-making guidelines, United States Coast Guard (http://www.uscg.mil/hq/g-m/risk/e-guidelines/RBDM/html/vol3/02/v3-02-cont.htm)
Fault Tree Analysis	Fault Tree Analysis is a deductive (top-down) method used for identification and analysis of conditions and factors that can result in the occurrence of a specific failure or undesirable event. This method addresses multiple failures, events, and conditions.	A discussion and worked example can be found in *Guidelines for Hazard Evaluation Procedures*, *Second Edition with Worked Examples,* Center for Chemical Process Safety, American Institute of Chemical Engineers, 1992.
Event Tree Analysis	This method is an inductive approach used to identify and quantify a set of possible outcomes. The analysis starts with an initiating event or initial condition and includes the identification of a set of success and failure events that are combined to produce various outcomes. This method identifies the spectrum and severity of possible outcomes and determines their likelihood.	A discussion and worked example can be found in *Guidelines for Hazard Evaluation Procedures*, *Second Edition with Worked Examples,* Center for Chemical Process Safety, American Institute of Chemical Engineers, 1992.
Probabilistic Risk Assessment	A Probabilistic Risk Assessment (PRA) is an organized process for answering the following three questions: 1. What can go wrong? 2. How likely is it to happen? 3. What are the consequences?	A detailed description of this method can be found in *Guidelines for Chemical Process Quantitative Risk Analysis*, Center for Chemical Process Safety, American Institute of Chemical Engineers, 2000.
Others	Other methods or combinations of methods, including those developed by the project team's organization, may be used.	See *Guidelines for Hazard Evaluation Procedures*, *Second Edition with Worked Examples,* Center for Chemical Process Safety, American Institute of Chemical Engineers, 1992.

Appendix II – Risk Binning Matrix[2]

Risk binning is one analysis tool used to classify vulnerabilities. Each vulnerability can be assigned a qualitative risk using a frequency-consequence matrix, such as the one shown below. Highest consequences are generally assigned to events that could reasonably result in an unintended release of hazardous material, destruction of equipment and/or facilities, or injury to people.

Risk Binning Matrix: Frequency/Consequence Criteria

		Frequency			
		Beyond extremely unlikely	**Extremely unlikely**	**Unlikely**	**Anticipated**
Consequence	**High**		7	4	1
	Moderate	10	8	5	2
	Low		9	6	3
	Negligible	12	11		

Higher risk

Lower risk

Moderate risk

Negligible risk

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[2] *Preliminary Safety Evaluation for Hydrogen-fueled Underground Mining Equipment*, DA. Coutts and J.K. Thomas, Westinghouse Safety Management Solutions, Aiken, SC, Publication WSRC-TR-98-00331, September 1998. (This reference includes information from *Preparation Guide for US Department of Energy Nonreactor Nuclear Facility Safety Analysis Reports*, DOE-STD-3009-94, July 1994.)

Frequency criteria used for risk-binning

Acronym	Description	Frequency level
A	Anticipated, Expected	> 1E-2/yr
U	Unlikely	1E – 4 < f ≤ 1E – 2/yr
EU	Extremely Unlikely	1E – 6 < f ≤ 1E – 4/yr
BEU	Beyond Extremely Unlikely	≤ 1E – 6/yr

Consequence criteria used for risk-binning

Consequence Level	Impact on Populace	Impact on Property/Operations
High (H)	Prompt fatalities Acute injuries – immediately life threatening Permanent disability	Damage > $50 million Production loss in excess of 1 week
Moderate (M)	Serious injuries Non-permanent disability Hospitalization required	$100,000 < damage ≤ $50 million Equipment destroyed Critical equipment damaged Production loss less than 1 week
Low (L)	Minor injuries No hospitalization	Damage ≤ $100,000 Repairable damage to equipment Significant operational down-time Minor impact on surroundings
Negligible (N)	Negligible injuries	Minor repairs to equipment required Minimal operational down-time No impact on surroundings

Appendix III – Example Project Safety Plan Approval Form

DOE Award Number: ____

Project Title: ____

Organization: ____

Safety Plan submitted by: ____

The attached safety plan is being submitted to the U.S. Department of Energy in compliance with the Fuel Cell Technologies Program requirement under the terms of the above-referenced award. The completed approvals noted below are consistent with organization's policy for such submittals.

Project safety plan prepared by: (**EXAMPLE:** Primary Author/PI)

Name
Title
Department/Division

Project safety plan reviewed by: (**EXAMPLE:** Next Level of Management Above PI)

Name
Title
Department/Division

Project safety plan approved by: (**EXAMPLE:** Organization's Safety Representative)

Name
Title
Department/Division

Appendix IV – Safety Plan Checklist

This checklist is a summary of desired elements for safety plans. The checklist, referring to page numbers in this document, is intended to help project teams verify that their safety plan is complete and can be a valuable tool over the life of the project.

Page	Element	The Safety Plan Should Describe
1	**Scope of Work**	• Nature of the work being performed
3	**Organizational Policies and Procedures**	• Application of organizational safety-related policies and procedures to the work being performed
3	**Hydrogen and Fuel Cell Experience**	• How previous organizational experience with hydrogen, fuel cell and related work is applied to this project
4	**Identification of Safety Vulnerabilities (ISV)**	• What is the ISV methodology applied to this project, such as FMEA, What If, HAZOP, Checklist, Fault Tree, Event Tree, Probabilistic Risk Assessment, or other method • Who leads and stewards the use of the ISV methodology • Significant accident scenarios identified • Significant vulnerabilities identified • Safety critical equipment • Storage and Handling of Hazardous Materials and related topics o ignition sources; explosion hazards o materials interactions o possible leakage and accumulation o detection • Hydrogen Handling Systems o supply, storage and distribution systems o volumes, pressures, estimated use rates
4	**Risk Reduction Plan**	• Prevention and mitigation measures for significant vulnerabilities

Page	Element	The Safety Plan Should Describe
4	**Operating Procedures**	• Operational procedures applicable for the location and performance of the work including sample handling and transport • Operating steps that need to be written for the particular project: critical variables, their acceptable ranges and responses to deviations from them
5	**Equipment and Mechanical Integrity**	• Initial testing and commissioning • Preventative maintenance plan • Calibration of sensors • Test/inspection frequency basis • Documentation
6	**Management of Change Procedures**	• The system and/or procedures used to review proposed changes to materials, technology, equipment, procedures, personnel and facility operation for their effect on safety vulnerabilities
6	**Project Safety Documentation**	• How needed safety information is communicated and made available to all project participants, including partners. Safety information includes the ISV documentation, procedures, references such as handbooks and standards, and safety review reports.
7	**Employee Training**	• Required general safety training - initial and refresher • Hydrogen-specific and hazardous material training - initial and refresher • How the organization stewards training participation and verifies understanding
7	**Safety Reviews**	• Applicable safety reviews beyond the ISV described above

Page	Element	The Safety Plan Should Describe
7	**Safety Events and Lessons Learned**	• The reporting procedure within the organization and to DOE • The system and/or procedure used to investigate events • How corrective measures will be implemented • How lessons learned from incidents and near-misses are documented and disseminated
9	**Emergency Response**	• The plan/procedures for responses to emergencies • Communication and interaction with local emergency response officials
9	**Self-Audits**	• How the project will verify that safety related procedures and practices are being followed throughout the life of the project
9	**Safety Plan Approval**	• Safety plan review and approval process
9	**Other Comments or Concerns**	• Any information on topics not covered above • Issues that may require assistance from DOE