Graduate student perspective on the ACS online tool *Hazard Assessment in Research Laboratories*

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HAZARD ASSESSMENT In Research Laboratories

Hazard Assessment | Fundamentals | Ways to Conduct Assessments | Tools

Safety in the laboratory requires a full team effort to be successful. When everyone in the laboratory understands how to identify hazards, assess risk, and select the appropriate control measures to eliminate a hazard or minimize risk, accidents, injuries and near misses can be reduced.

https://www.acs.org/hazardassessment

Hazard vs. Risk

KNOW THE DIFFERENCE BETWEEN A HAZARD AND A RISK

"Hazard" and "risk" are NOT the same.

Hazard	**Risk**
• A hazard causes harm. • A hazard can be eliminated, but not reduced.	• Risk is the probability that a hazard will cause harm. • Risk associated with a hazard can be reduced.

Risk = hazard x exposure

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- Chemical
- Electrical
- Ergonomics
- Excavation
- Fall
- Fire/Heat
- Mechanical
- Noise
- Radiation
- Struck By
- Struck Against
- Temperature Extreme
- Visibility
- Weather

Risk = hazard x exposure

- **Isolation**
  Reduce or remove hazards by separation in time or space. (May be particularly helpful in a shared lab space where different types of chemicals are being used.)
- **Enclosure**
  Place the material or process in a closed system.
- **Transportation**
  Move hazardous materials where fewer workers are present.
- **Guarding and shielding**
  Install guards to provide protection from moving parts or electrical connections.
  Shielding provides protection from potential explosions
- **Ventilation**
  Use fume hoods, fans, air ducts and air filters.

Eye goggles, hearing protection, and protective clothing (e.g., lab coats and gloves) are the most recognizable and most used PPE in the lab.

Determine the Scope

Collect Appropriate Background Information

The analysis team will need appropriate background information, including:

- Equipment diagrams
- A list describing common hazards associated with chemicals and gases
- A list of the equipment's chemical and gas compositions, operating pressures, flow rates, run times, and other applicable parameters
- Potential health and physical hazards of equipment (e.g., ionizing or nonionizing radiation, high temperature, high voltage, or mechanical pinch points)
- Equipment safety features (e.g., interlocks)
- Physical access to equipment, as necessary/possible

Safety Data Sheets can include a lot of this information.

Assemble Your Team

Assemble Your Team

Everyone should be involved in hazard assessment, regardless of experience level or title in the lab.

Everyone is responsible for familiarizing themselves with appropriate controls for the hazards discovered in the lab.

Everyone is responsible for participating in hazard analyses (checklists, Job Hazard Analysis, and What-if Analysis) and the updating of the lab's Standard Operating Procedures. This is also a good time to review accidents, incidents, and near misses and collectively brainstorm ways to prevent these events in the future.

More experienced members of the team should lead risk assessment activities and assign risk ratings to the materials and processes in your lab.

Learn about the roles and responsibilities of various people in the lab.

Assemble Your Team

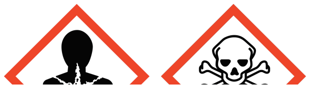
PI's job:

- Promote a laboratory culture where safety is a valued component of research;
- Analyze proposed work tasks to identify hazards and determine the appropriate controls (engineering, administrative, and PPE) needed to sufficiently mitigate the hazards;
- Seek ways to make hazard analysis an integrated part of the research process, so that it becomes a natural part of the process;
- Include the researchers who will be performing the work in the hazard analysis process;
- Ensure the hazards and controls are clearly communicated and understood by those performing the task;
- Set the expectation that participation in the research project is contingent on an individual contributor's willingness to abide by the controls established through the hazard analysis process;
- Reach out to support personnel and subject matter experts for assistance, as needed, and defer to their expertise regardless of their position on the research team or within the organization (e.g., junior staff members or safety professionals);
- Meet with research staff on a regular basis and lead by example;
- Engage in the daily operations of the laboratory and be available, as needed, to ensure workers are performing in accordance with the agreed upon controls;
- Use lessons learned from abnormal events inside and outside the research group to improve planning;
- Solicit feedback from coworkers and colleagues to improve safety and the process;
- Address risks faced by visitors, including maintenance staff, during the hazard analysis process;
- Manage change control carefully by routinely reviewing procedures and the hazard analysis to identify changes; and
- Ensure training is appropriate, effective, and documented.

Use lessons learned

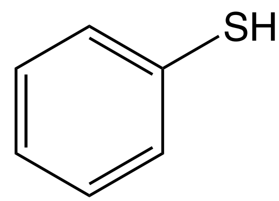
Mack Lab Safety Form for Ordering Toxic Chemicals

It is mandatory to fill out this form if the chemical you are ordering is labeled with any of the following HCS Pictograms:



GHS Label elements, including precautionary statements

Pictogram



Chemical name:

Chemical structure:

Using the MSDS or SD
hazards, including rou

Signal word	Danger
Hazard statement(s)	
H226	Flammable liquid and vapour.
H300 + H310 + H330	Fatal if swallowed, in contact with skin or if inhaled
H315	Causes skin irritation.

$LC_{50} \leq$ 2.0 mg/L

Provide a detailed exp

h - T32808

For each of the human
here using the table b
obtained from the MS
sources.

Hazard Statement	LD_{50}

H319	Causes serious eye irritation.
H335	May cause respiratory irritation.
H361	Suspected of damaging fertility or the unborn child.
H371	May cause damage to organs (Nervous system) if swallowed.
H372	Causes damage to organs (Kidney) through prolonged or repeated exposure if swallowed.
H410	Very toxic to aquatic life with long lasting effects.

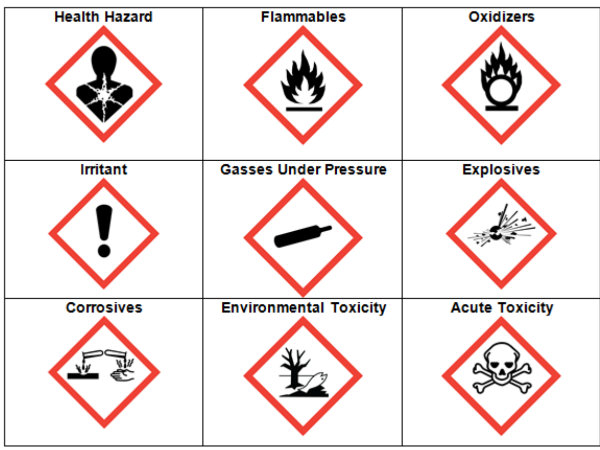
What alternatives to t
for this chemical?

Now that the possible consequences of using this chemical have been described, please explain how the benefits to your research outweigh the potential costs to our health.

https://ehs.unl.edu/sop/s-health_hazards_haz_assessment_risk_min.pdf

Conducting a Hazard Assessment

Identify hazards → Analyze risks → Select controls



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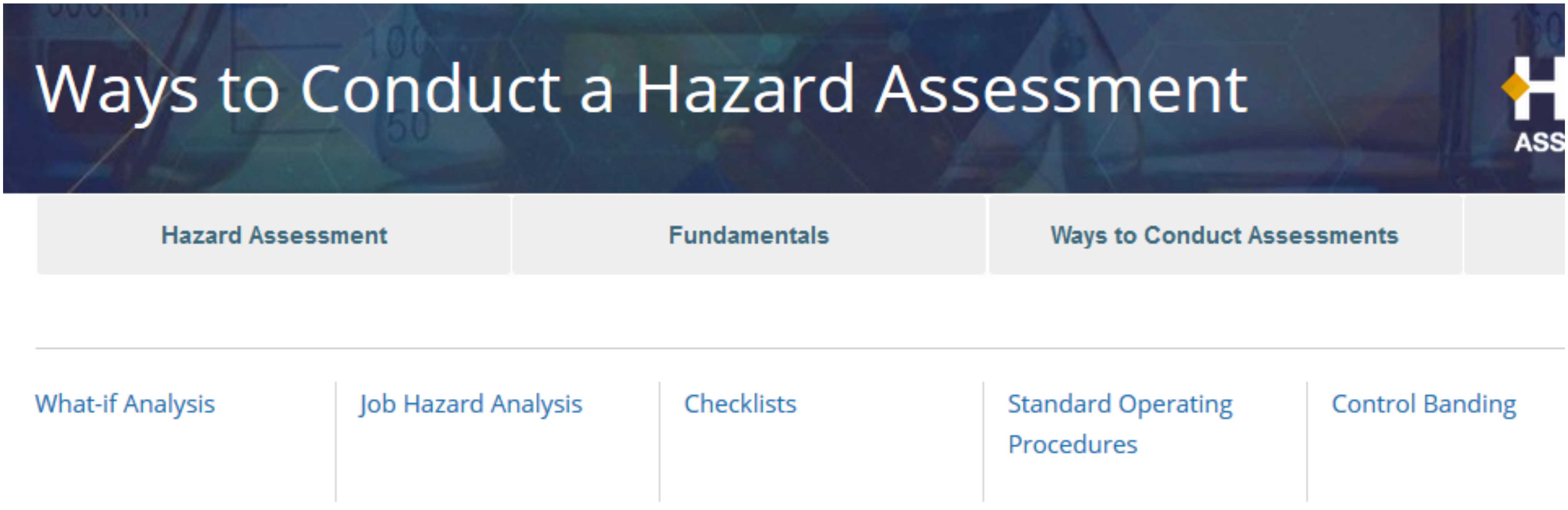

Identify hazards → Analyze risks → Select controls

How to Conduct a Job Hazard Analysis

1. Involve people working in the lab.

The JHA should be developed in collaboration with the people performing the work from the beginning. Involving researchers in the process helps to minimize oversights. (People on the "frontline" have the best understanding of their processes.)

2. Review accident history and literature.

Key items to review include related accidents and illnesses, losses that required repair or replacement, and near-misses.

3. Conduct a preliminary review.

Review current tasks and conditions weekly. Brainstorm ideas to eliminate or mitigate hazards. Stop work if immediately dangerous to life or health (IDLH) hazards are uncovered during the review. Work must cease until proper controls can be implemented to protect the workers.

4. List, rank, and set priorities.

Research that involves hazards with unacceptable risks (based on high probability of occurrence and severity of consequence) should take top priority for analysis.

> *Risk is the probability that a hazard will result in an adverse consequence. Assessing risk helps to determine the proper mitigation strategy and priorities. Risk ratings and scaling can show where additional resources are required.*

5. Assign risk.

Assigning numerical values to risk must be done by individuals with a thorough knowledge of the hazard.

Calculate Risks Using Probability of Occurrence and Severity of Consequences Scaling

Many risk assessments use "probability of occurrence" and "severity of consequences" scales to rate risks associated with laboratory experiments. They are comprehensive assessment tools and provide greater differentiation of risks based on actual laboratory operations.

Using this kind of scaling, laboratory hazard risk rating is calculated as follows:

Risk Rating (RR) = Probability of Occurrence (OV) x Severity of Consequences Value (CV)

As the formula indicates, the higher the assessed probability of occurrence and severity of consequences, the greater the risk rating will be.

Identify hazards → Analyze risks → Select controls

Probability of Occurrence with Standard Linear Scaling

Occurrence Value (OV)		Probability of Occurrence	
Rating	**Value**	**Percent**	**Description**
Not Present	0	0%	Item/operation is not present in laboratory.
Rare	1	1–10%	Rare
Possible	2	10–50%	Possible
Likely	3	50–90%	Likely
Almost Certain to Certain	4	90–100%	Almost Certain to Certain

Risk Rating (RR) = Probability of Occurrence (OV) x Severity of Consequences Value (CV)

Identify hazards → <u>Analyze risks</u> → Select controls

Severity of Consequences, Weighted Value Scale

Consequence Value (CV)		Impact to...				
Rating	**Value**	**Personnel Safety**	**Resources**	**Work Performance**	**Property Damage**	**Reputation**
No Risk	1	No injuries	No impact	No delays	Minor	No impact
Minor	5	Minor injuries	Moderate impact	Modest delays	Moderate	Potential damage
Moderate	10	Moderate to life impacting injuries	Additional resources required	Significant delays	Substantial	Damaged
High	20	Life threatening injuries from single exposure	Institutional resources required	Major operational disruptions	Severe	Loss of confidence

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Moderate	3	Moderate to life impacting injuries	Additional resources required	Significant delays	Substantial	Damaged
High	4	Life threatening injuries from single exposure	Institutional resources required	Major operational disruptions	Severe	Loss of Confidence

high probability x no consequences = 4
low probability x life threatening consequences = 4

Identify hazards → Analyze risks → Select controls

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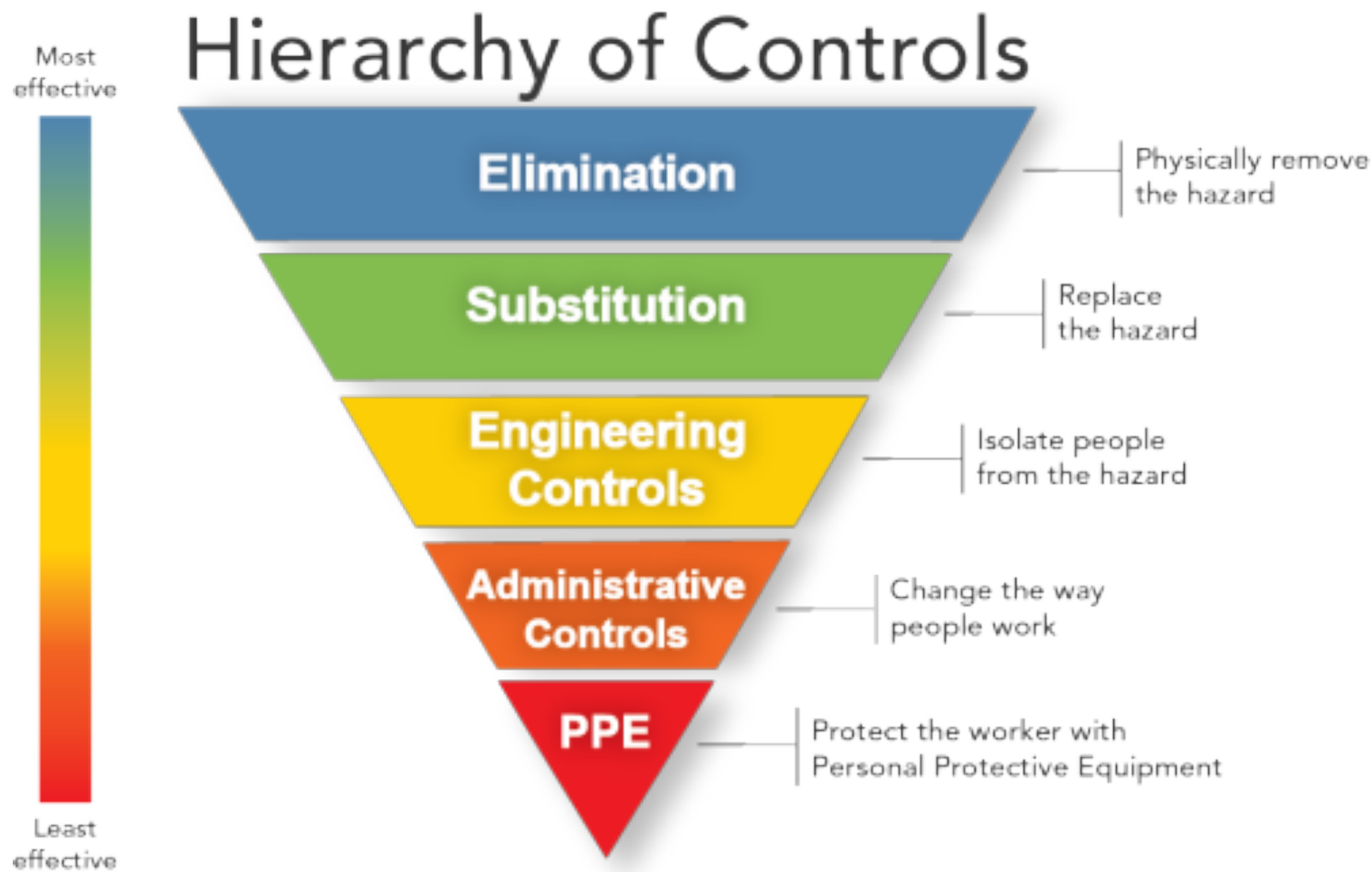
Moderate	10	Moderate to life impacting injuries	Additional resources required	Significant delays	Substantial	Damaged
High	20	Life threatening injuries from single exposure	Institutional resources required	Major operational disruptions	Severe	Loss of confidence

high probability x no consequences = 4
low probability x life threatening consequences = 20

Identify hazards → Analyze risks → Select controls

Job Hazard Analysis			
Job Location: Rieveschl Hall, UC	**Laboratory Group: Mack**	**Date: 03/14/2017**	
Activity or Job	**Run oxidation experiment**		
Completed By	**Kendra**		
Equipment and Chemicals Required	**Stainless steel vial + cap, o-ring, stainless steel ball, balance, ball mill, glass pipette, rubber pipette bulb, metal spatula, benzyl alcohol, PS-TEMPO, Oxone**		
Work Steps and Tasks *Describe the tasks or steps involved in the work in the order performed*	**Hazards Identified for each Task/Step**	**Risk Level** *Risk Nomogram can be used (see APPENDIX B)*	**Control/Safe Work Procedures for each Task/Step** *Controls to be implemented*
Weigh out benzyl alcohol	Harmful if swallowed	1 x 5 = **5**	Use PPE; discard contaminated gloves immediately; wash hands upon exiting lab
	Harmful if inhaled	2 x 5 = **10**	Weigh under snorkel
	Causes serious eye irritation	1 x 5 = **5**	Use PPE; discard contaminated gloves immediately; wash hands upon exiting lab
Weigh out PS-TEMPO	None (not a hazardous substance/mixture)	1 x 1 = **1**	None
Weigh out Oxone	Harmful if swallowed	1 x 5 = **5**	Use PPE; discard contaminated gloves immediately; wash hands upon exiting lab
	Causes severe skin burns and eye damage	1 x 5 = **5**	
Clamp vial in ball mill and start ball mill	Caught in ball mill	2 x 5 = **10**	Use care when opening and closing the ball mill
Hazards Checklist [Note: This section can be modified, as needed. See Table D-1: Common Hazards and Descriptions in APPENDIX D.]			
Can someone be exposed to chemicals? Yes	*If so, what is the nature of the chemical hazard?* Ingestion and inhalation hazards; eye and skin irritation		
Can someone slip, trip, or fall? Yes	*Can someone injure someone else?* Yes		
Can someone be caught in anything? Yes	*Can someone strike against or make contact with any physical hazards?* Yes		

Identify hazards → Analyze risks → Select controls



Source: http://www.cdc.gov/niosh/topics/hierarchy

Elimination and Substitution

The San Destin Declaration: 9 Principles of Green Engineering*

1. Engineer processes and products holistically, use systems analysis, and integrate environmental impact assessment tools.

Think about the amount of chemicals or potentially hazardous materials you are using. Can you reduce the amount and still achieve the desired result?

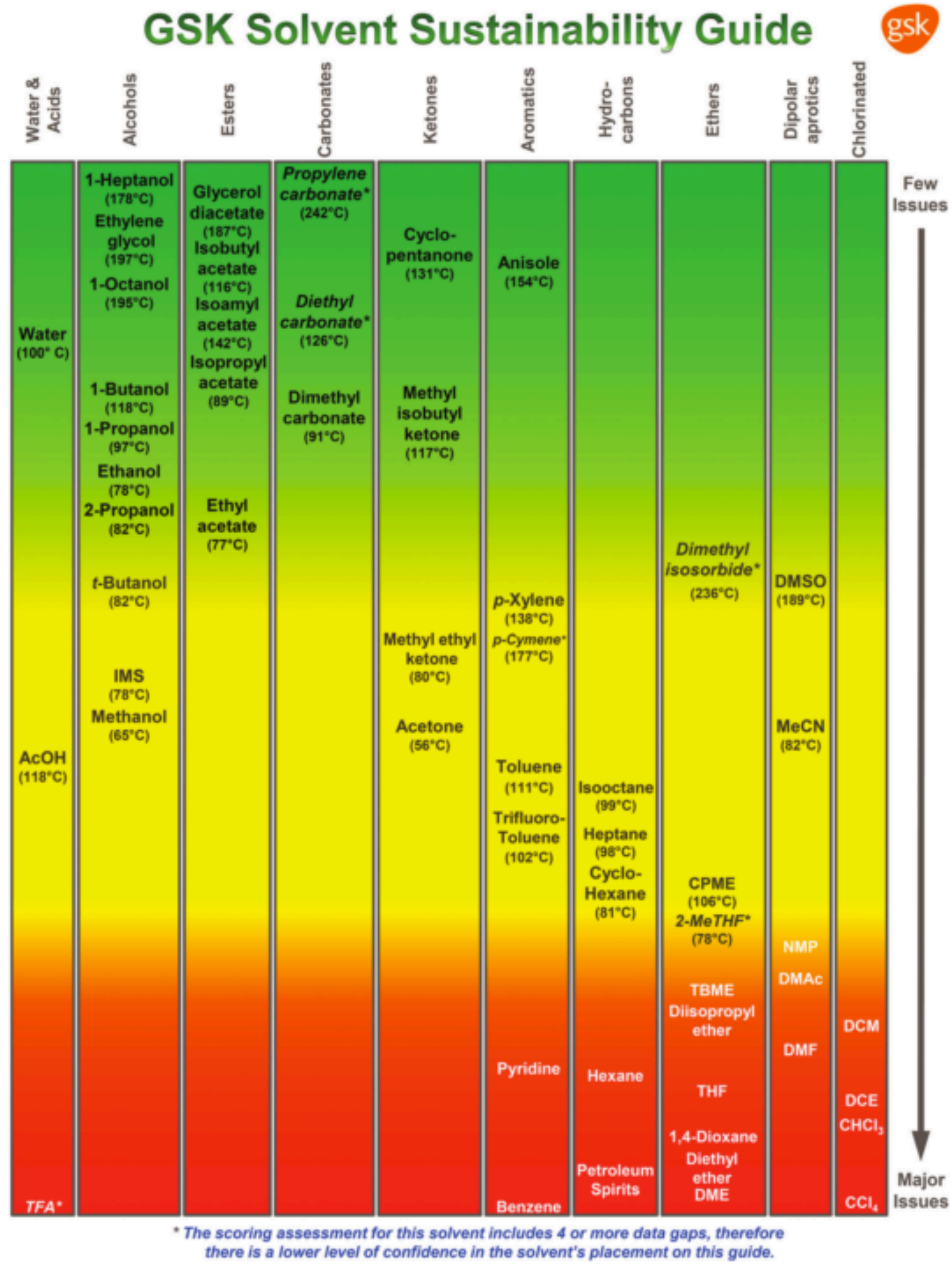
benign as possible.

5. Minimize depletion of natural resources.
6. Strive to prevent waste.
7. Develop and apply engineering solutions, while being cognizant of local geography, aspirations, and cultures.
8. Create engineering solutions beyond current or dominant technologies; improve, innovate, and invent (technologies) to achieve sustainability.
9. Actively engage communities and stakeholders in development of engineering solutions

by EPA, NSF, DOE (Los Alamos National Lab), and the ACS GCI.

*Abraham, M.; Nguyen, N. "Green engineering: Defining principles" – Results from the Sandestin conference. *Environmental Progress* **2004**, *22*, 233-236.DOI: 10.1002/ep.670220410

Source: ACS Green Chemistry Institute (GCI)



Alder, C. et. al. "Updating and further expanding GSK's solvent sustainability guide." *Green Chemistry*, **2016**, *4*, 1166-1169.

Tools

Common Hazards | Further Reading | Definitions of Hazard Assessment

Examples | Templates

What-If Analysis

- Analysis of a Wolff-Kishner reaction [Word]
- Entering an empty lab without wearing protective glasses [Word]*
- Inert materials and nonchemical effects: nitrogen backfill exceeds atmospheric pressure [Word]*
- Lockout or tagout principle for hazardous energy [Word]*
- Management of change: relocating moisture removal column [Word]*
- Material substitution: Hydrogen mixture replaced with pure hydrogen [Word]*
- Toxic or flammable gas cylinder in a fume hood [Word]
- Using a hotplate with flammable liquid [Word]

Job Hazard Analysis

- Analysis for neutralizing solution of glacial acetic acid, zinc sulfate heptahydrate, potassium chloride, and water [Word]

Checklists

- Chemical hazard assessment for sodium cyanide [Word]

Standard Operating Procedures

- SOPs for new process involving carbon monoxide [Word]
- SOP for use of carbon monoxide to create metal complexes under pressure [Word]

Control Banding

- Approach to establishing chemical safety levels [Word]

Risk Assessment

- Laboratory hazard risk assessment matrix [Word]
- Laboratory process risk assessment matrix [Word]
- Laboratory process risk assessment for a process using a chemical [Word]

Summary

- Risk = hazard x exposure
- Determine scope (use SDS!)
- Assemble your team
- Conduct a hazard assessment
  - Assigning risk ratings
  - Job hazard analysis
- Select controls
- Green engineering principles
- Hazard assessment is an **ongoing process**

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