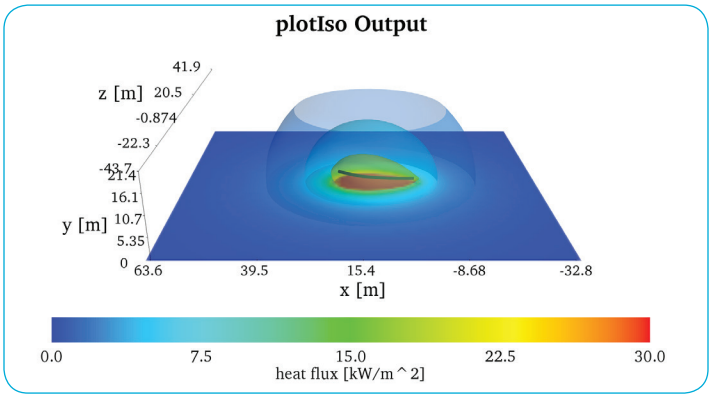
HyRAM
HYDROGEN RISK ASSESSMENT MODELS

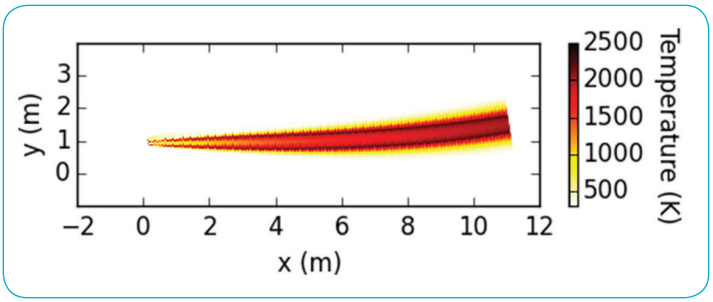
Overview

Developing hydrogen codes and standards is challenging because the relevant models and information span multiple science and engineering disciplines. The HyRAM toolkit integrates state-of-the-art models and data for assessing hydrogen safety. HyRAM provides a common platform for stakeholders conducting quantitative risk assessment and consequence analysis for hydrogen systems. The resulting information provides the scientific basis to ensure code requirements are consistent, logical, and defensible.

Features

- Generic data for gaseous hydrogen (GH2) systems: component leak frequencies, ignition probability; modifiable by users
- Models of GH2 physical effects for consequence modeling
  - Release characteristics (plumes, accumulation)
  - Flame properties (jet fires, deflagration within enclosures)
- Probabilistic models for human harm from thermal and overpressure hazards
- Fast running: to accommodate rapid iteration
- Calculates common risk metrics for user-defined systems: FAR, AIR, PLL; frequency of fires
- Ongoing development activities to add liquid hydrogen systems and features to add usability





Risk Metric	Value
PLL	7.362e-05
FAR	0.0168
AIR	3.362e-07

Scenario	End State Type	Avg. Events/Year
100pct Release	No Ignition	0.0008
10pct Release	No Ignition	0.0012
1pct Release	No Ignition	0.0015
0.1pct Release	No Ignition	0.0050
0.01pct Release	No Ignition	0.0348

Sample HyRAM output: plots of jet flame temperature and heat flux for user-defined hydrogen releases; PLL, FAR, AIR, and frequency of unignited releases from a user-defined hydrogen installation

Applications

- QRA and consequence calculations used to inform GH2 separation distances (NFPA 2, 2008)
- QRA results used to inform indoor fueling requirements (NFPA 2, 2011)
- Developed performance-based framework for establishing safety distances & mitigations (NFPA 2, 2016 and ISO TR-19880)
- Ongoing activities: Liquid hydrogen separation distance (NPFA 2, 2019)
- Future opportunities: Evacuation zone analysis, enclosure risk modeling

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Questions Addressed

Given a user-defined system, risk analysts can use HyRAM to answer the following types of questions:

- How would changes to system design affect overall risk? Which design is the safest? Will this enhance system safety? (If used with an economic model: is the increase in system cost justified?)
- What is the likelihood of a release from an installation? How likely is it that a jet fire or deflagration would occur ?
- What is the heat flux from a jet flame associated with a specific hydrogen release?
- At what distance does heat flux reach the no-harm threshold?

About Sandia's Hydrogen Program

Sandia's Hydrogen Program supports the nation's energy strategy —helping to diversify America's energy sector and reduce our dependence on foreign oil through the advancement of hydrogen and fuel cell technologies. HyRAM is developed for the U. S. Department of Energy Fuel Cell Technologies Office by Sandia National Laboratories.

References

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Sandia National Laboratories

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