Hydrogen and Fuel Cell Summit VIII

Miami, June 16, 2004

stuartenergy

the power of hydrogen

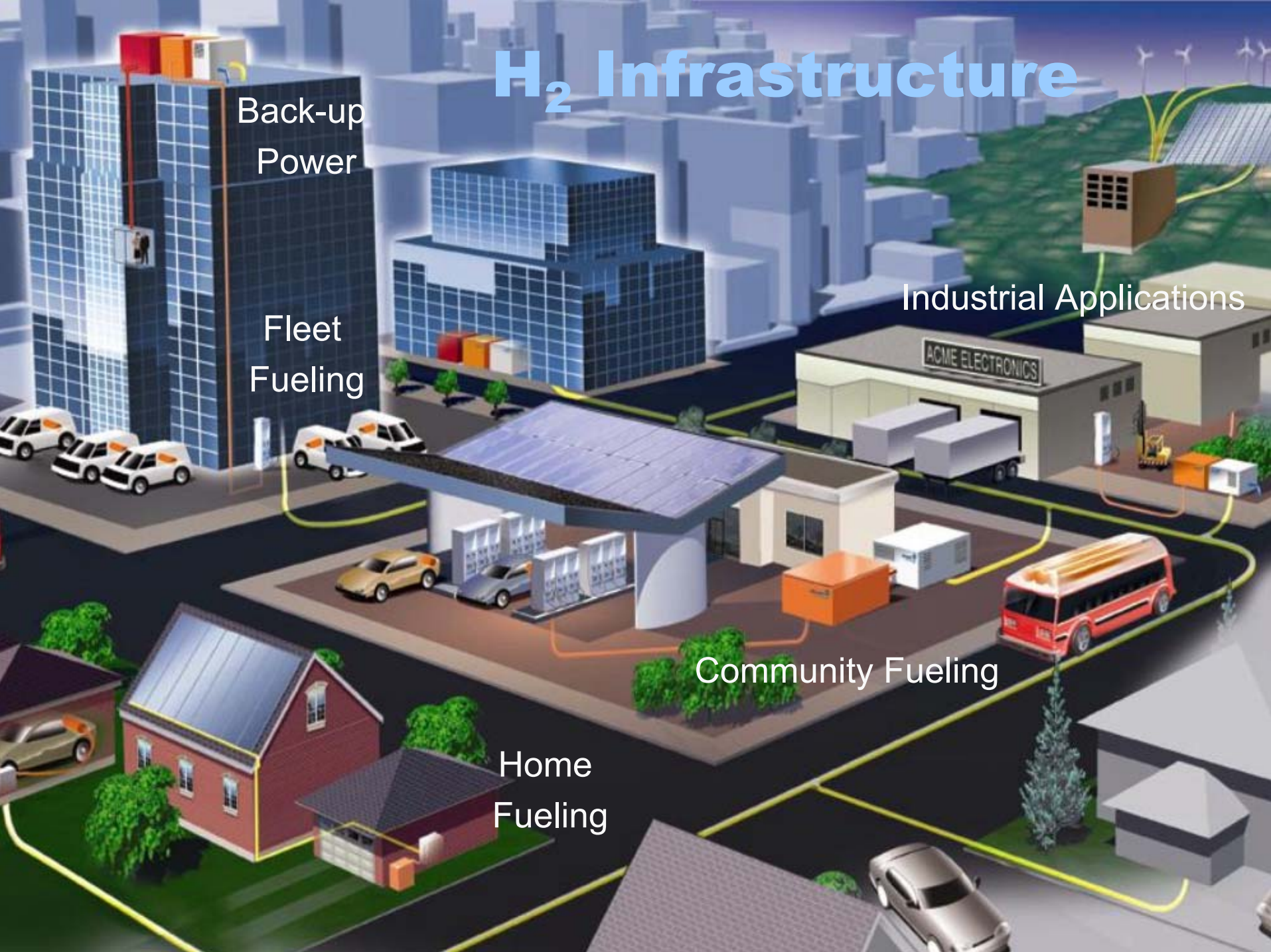
Hydrogen Energy Station for Back-Up Power and Vehicle Refueling

Stuart Energy Overview

- Located in Mississauga, Canada
- Pioneered water electrolysis hydrogen generation technology and infrastructure concept in 1905, founded Company in 1948
- Created world's first solar-powered hydrogen fuel station in California in 1995
- Built world's first commercial hydrogen fuel station in 1998 for Vancouver's Ballard fuel cell bus project
- Raised $150M in IPO on TSX in 2000 – ticker symbol HHO
- Completed $28M acquisition of Belgian Vandenborre Technologies in 2003
- Developed state of the art hydrogen infrastructure products

Stuart Energy Installations

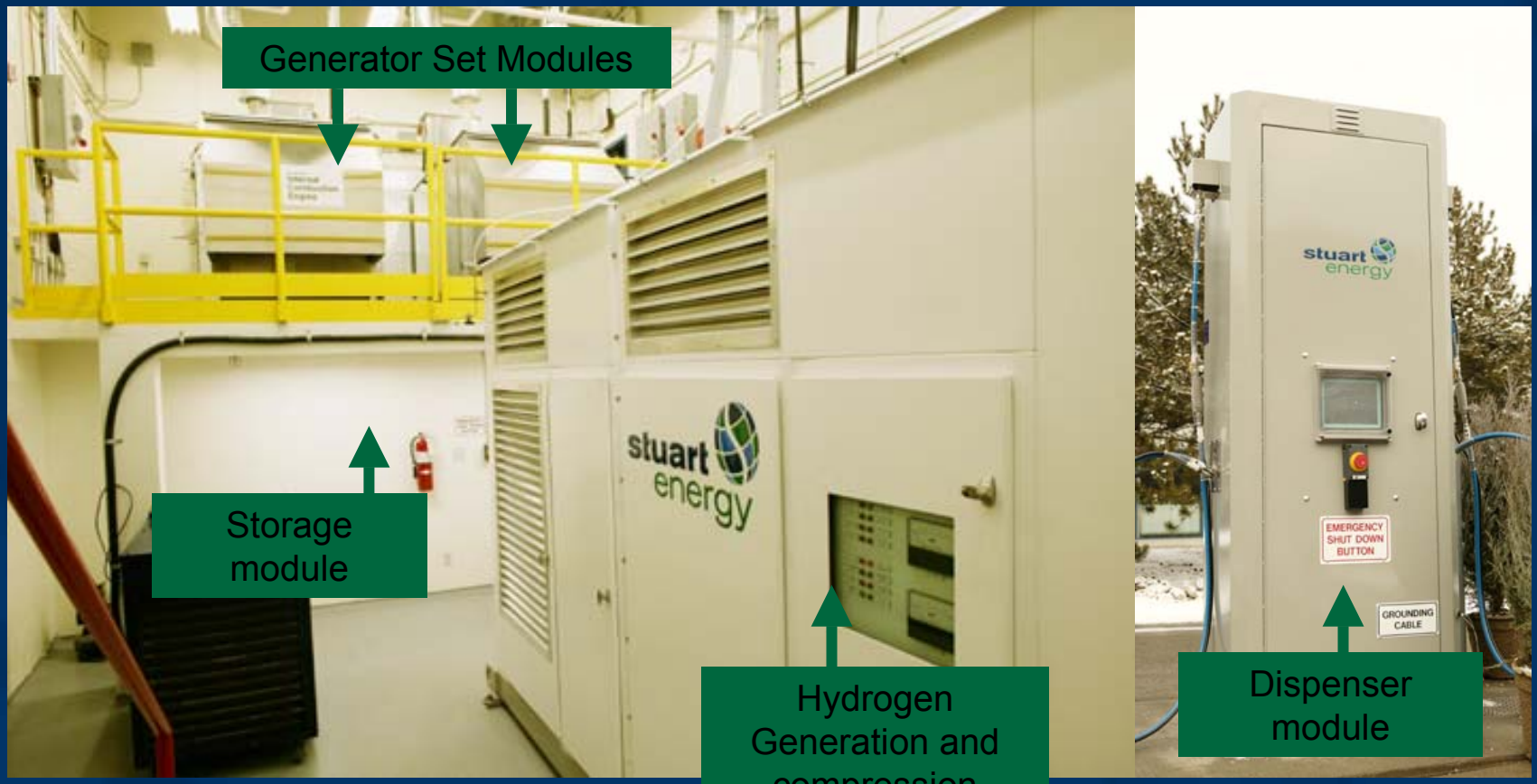
H_2 Infrastructure



Stuart Energy Stations Worldwide

Hydrogen Energy Station

Stuart Headquarters, Mississauga, Ontario



Major Components

The H2BPS Alpha will consist of:

- An SES CF 450 Hydrogen Generator producing 450 scfh of H2 at up to 6,000 psig operating pressure. The working pressure will be 5,000 psig.

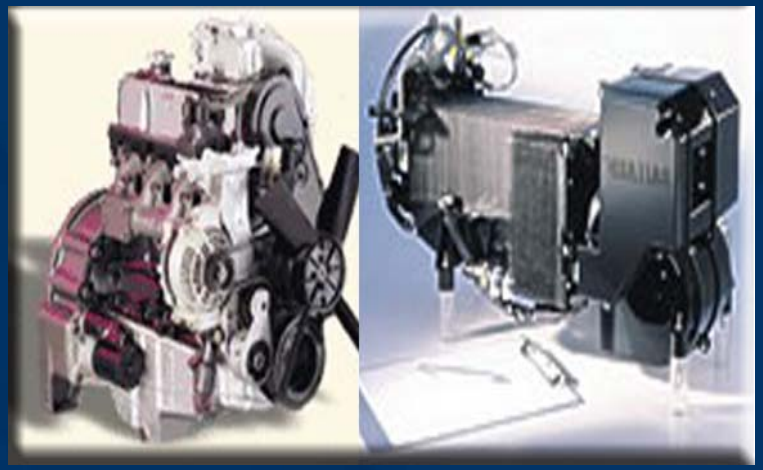
Major Components - *continued*

- High-pressure H2 storage is segmented into 3 separate banks of sufficient total capacity to allow the ICE to run approximately 3 hours under back-up power conditions. This requires 12 cylinders of compressed gas with combined storage capacity of 60 kg at a pressure of 5,000 psig (350 bar).

Hydrogen Storage

Major Components - *continued*

- Two identical Ford Power Products (FPP) hydrogen fueled, packaged ICE/generator sets that provide up to 120 kW of electrical output each complete with necessary electrical equipment to produce electricity in the form compatible with the critical building circuits to be backed up.

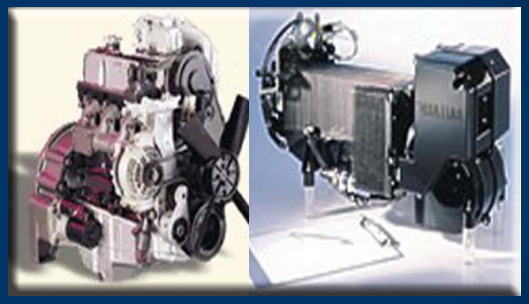


Genset using ICE or Fuel Cell

Integrated Solution

Stuart Hydrogen Fueler

Hydrogen Storage



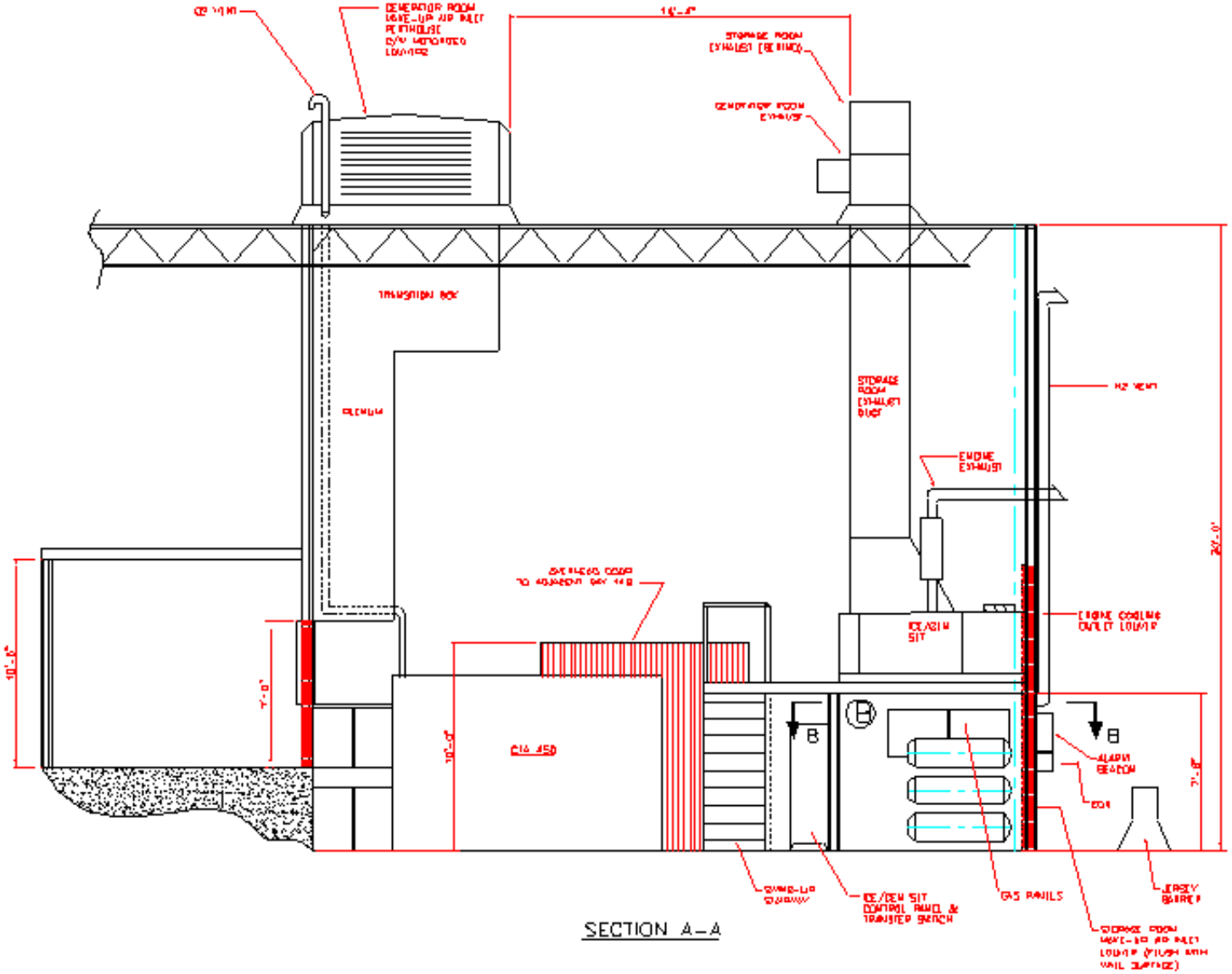
Genset using ICE or Fuel Cell

Electricity
+
Water

Transportation Application

Commercial Power Application

FACILITY OVERVIEW



Permits/Approvals Schedule

- Meeting with TSSA Fuels Safety Branch, Ont. Fire Marshall and Building Material Evaluation Commission to determine the process how to proceed – Oct 2001
- Initial submission to TSSA – Dec 2001
- Final submission to TSSA – Mar 2002
- TSSA Field Development Project approval – Leave To Construct – May 2002
- Other permits – May-Dec 2002
- Ontario Ministry of Labour – PreStart Review – Jan 2003
- Grand Opening – Feb 2003

Permits/Approvals Steps

- TSSA Fuels Safety Branch Leave to Construct
  - Determine TSSA jurisdiction
  - Prepare drawings, manuals, etc. for application
  - Ont. Fire Marshall agreed TSSA has responsibility
- TSSA Field Development Project approval
- (TSSA permanent approval application in 2005)
- City of Mississauga Building Permit
  - Fire, Electrical, Plumbing, Structural, Mechanical
- Ontario Air permit
- Third party (Entela) approval of electrical components
- Electrical Safety Authority permit to connect to mains
- Design review with insurance broker
- Ontario Ministry of Labour – PreStart Review

Regulations, Codes & Standards

- TSSA – Compressed Natural Gas Code Adoption Document
- Ontario Regulations for Compressed Natural Gas
- CSA B108-99 Natural Gas Fuelling Stations Installation Code
- CSA C282-00 Emergency Electrical Power Supply for Buildings
- CSA B51 Boiler, Pressure Vessel and Piping Code
- ANSI/ASME B31.3 Process Piping
- Canadian/Ontario Building Codes (City of Mississauga Building Permit)
- Ontario Fire Code (deemed to be not applicable)
- Canadian Electrical Code
- Ontario Ministry of Environment Air permit
- NFPA 69 Std. on Explosion Prevention Systems

FMEA Analysis

- 77 potential failure modes were reviewed
- The FMEA resulted in a total risk score of 888 out of possible score of 75,000 or 1.2%
- The risk score is relatively low due to the risk mitigation strategies employed throughout the design
- The low risk suggests that the design is appropriate to the risk factors associated with the installation

Computational Fluid Dynamics (CFD) Modeling of H_2 Releases

- Purpose: to simulate behavior of H2 releases under various conditions / geometries to determine correct separation distances and zoning requirements, and to validate ventilation system designs for:
  - H2 Storage (outdoors and indoors)
  - Garages
  - Fueling Stations
  - Buildings

Hydrogen Release into Generator Room: Fast Release

Constant flow rate:

79.72 CFM (0.03762 m^3/s)

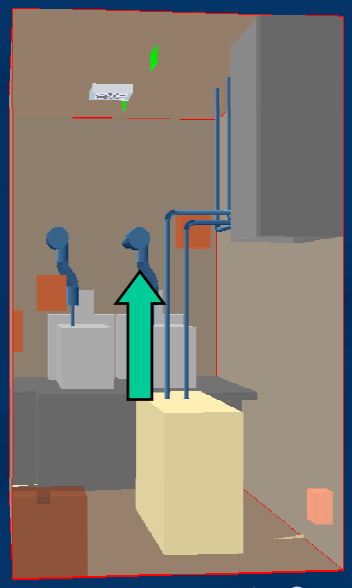
Leak orifice:

¼" , from a high-pressure line

Ventilation systems: down

Duration: 10 sec. leak

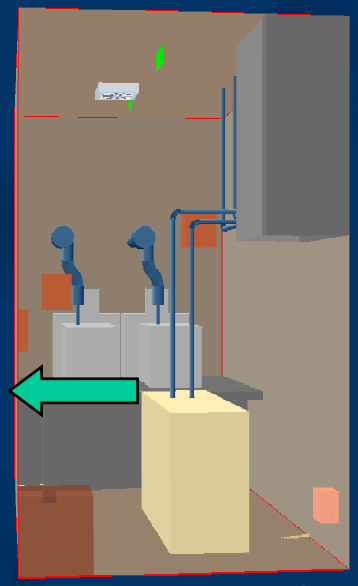
Vertical



Fast Leak

After Leak

Horizontal



Fast Leak

After Leak

Approval Process Results

- *The Fuels Safety Division of TSSA stated:*
  - *At present time, there are no specific regulations, codes or standards that would address the installation of this system. However, due to similarities of H2 characteristics and properties, its storage and utilization can be compared to compressed natural gas for which there are a complete set of codes and standards.*
- *The Fire Marshal wrote:*
  - *…the installation of the H2BPS system at your premises falls under the jurisdiction of TSSA since hydrogen is being used as a fuel.*
- *City of Mississauga stated:*
  - *It has been established that CSA B108 is an acceptable design standard*

Key Issues for Approvals

- Determine leading Authority Having Jurisdiction (AHJ)
- Determine approval process by the AHJ
- Select appropriate Model Codes acceptable by the AHJ
- Determine permits (land, air, building, electrical, hazmat, etc.) required
- Identify and address key technical issues/field certification
- Review previous experiences with most appropriate AFV refueling and their support infrastructure
- Deal with insurance/risk management issues
- Arrange for education / buy-in of key stakeholders
- Arrange for training of station operators and support staff