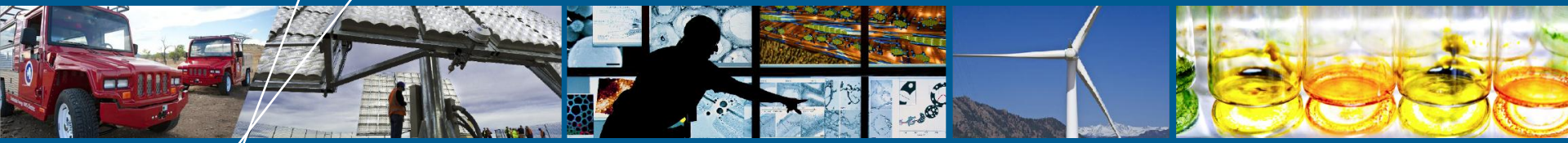
Hydrogen Contamination Workshop Deployment Requirements



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Hydrogen Safety Codes and Stands Group

DOE Hydrogen Contamination Workshop

Troy, Michigan

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Outline of talk

- **SAE 2719 Requirements and the HCD Detector**
- **Application Scenarios**
  - Discreet vs. “real-time”
  - Centralized vs. On-site
- **Sensor Performance Parameters**
  - Metrological, Operational, Deployment
- **Critical Metrics**
- **Measurement Strategies**
  - prescriptive vs. performance

SAE 2719: Hydrogen Fuel Quality for Fuel Cell Vehicles

- Allowable amount for "zero impact" *over life of vehicle*
- Harmonized with ISO 14687-2
- Produced H_2 ≠ Dispensed H_2

Constituent	SAE J2719 Limits (µmol/mol)	www.SmartChemistry.com Detection Limits (µmol/mol)	Method
Water	5	1	ASTM D7649-10
Total Hydrocarbons (C_1 Basis)	2		
Methane		0.001	ASTM D5466
Ethane, Ethene, Ethyne		0.01	ASTM D5466
Other Hydrocarbons (Smart Chemistry Detection Limit is for individual compound of hydrocarbon)		0.001	ASTM D5466
Oxygen	5	2	ASTM D7649-10
Helium	300	10	ASTM D1946
Nitrogen, Argon	100		
Nitrogen		5	ASTM D7649-10
Argon		1	ASTM D7649-10
Carbon Dioxide	2	1	ASTM D7649-10
Carbon Monoxide	0.2	0.001	ASTM D5466
Total Sulfur	0.004	0.0001	ASTM D7652-11
Hydrogen Sulfide		0.00002	ASTM D7652-11
Carbonyl Sulfide		0.00002	ASTM D7652-11
Methyl Mercaptan		0.00002	ASTM D7652-11
Carbon Disulfide		0.00002	ASTM D7652-11
Formaldehyde	0.01	0.001	ASTM D5466
Formic Acid	0.2	0.001	ASTM D5466
Ammonia	0.1	0.04	ASTM D5466
Total halogenates	0.05		
Chlorine		0.001	ASTM WK34574
Hydrogen Chloride		0.001	ASTM WK34574
Hydrogen Bromide		0.01	ASTM WK34574
Organic Halides (32 compounds Analyzed) (Smart Chemistry Detection Limit is for individual organic halide compound)		0.001	ASTM WK34574
Particulate Concentration	1 mg/kg	0.025 mg/kg	ASTM D7651-10
Particulates Found & Size	< 10µm		ASTM D7634-10
Gaseous Sampling at Nozzle			ASTM D7650-11
Particulate Sampling at Nozzle			ASTM D7650-10

From SmartChemistry.com

Application Scenarios

Centralized vs. On-site

- Produced H_2 ≠ Dispensed H_2
- On-site HCD needed

Discreet vs. “real-time”

- Frequency of measurements

Overview of Sensor Performance Metrics

- **Metrological parameters.** Selectivity, Accuracy, Analyte(s), Lower Detection Limit (LDL), Resolution, Linear Range (and Dynamic Range), Measuring Range, Response Time, Recovery Time, Repeatability, Drift, Environmental Effects (e.g., temperature [T], pressure [P], and relative humidity [RH]), Reversibility, Limits of Quantification, Saturation Stability, Sensitivity
- **Deployment parameters** Capital Cost, Installation Costs, Placement, Physical Size, Control Circuitry, Power Requirement, Electronic Interface, Pneumatic Design, Shelf Life, Maturity/Availability, Regulations (Codes), Alarm Set Points
- **Operational Parameters** Operational Lifetime, Consumables, Calibration and Maintenance Requirements, Sample Size, Matrix Requirements, Signal Management, Orientation Effect, Mechanical Stability, Orientation Effects, Device to Device Repeatability, Warm Up Time, Alarm Interface, Mechanical Stability, Manual Inputs

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Critical Sensor Performance Metrics

- **Metrological parameters.**
  - Analyte(s)
  - Lower Detection Limit
  - Response Time
- **Deployment parameters**
  - Capital Cost, Installation Costs
- **Operational Parameters**
  - Calibration and Maintenance Requirements
  - Manual Inputs

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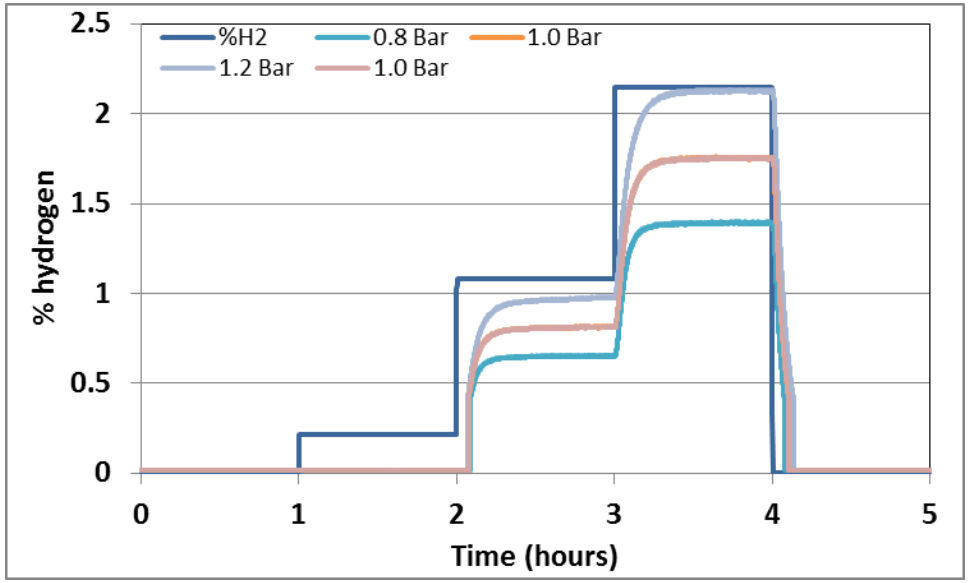
Measurement Strategies

- **Prescriptive**
  - Analytes defined by SAE 2719
  - Defined or agreed upon concentration requirements
  - Provide stakeholders verification of compliance
  - “Commercially available” but not necessarily for market
  - Discussed in more detail by Andrew Kaldor
- **Performance**
  - Non-selective, indirect
  - Often based on surrogate miniature fuel cell system
  - Developmental technology, with gaps (response time, calibration protocols)
  - Discussed in more detail by Rangachary Mukundan

Quirks of (some) sensor technolgoy

- **SAE 2719 regulates to volume fraction (V_f)**
- **Many sensors respond to partial pressure (P_i)**
  - $P_i = P_{total} * (V_f)_i$
  - A 10 fold increase in pressure may yield a 10 fold increase in sensitivity
  - Sensors not currently designed for hi P deployment



Gaps

- Allowable “short term” exposure limits
- Critical species or all-inclusive
- Detection limits/interface design
- Prescriptive or performance based strategies

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THANK YOU

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