

Appendix C – Hydrogen Quality

The hydrogen fuel quality specification in Table C.1 below is based on the SAE International Surface Vehicle Standard *SAE-2719 - Hydrogen Fuel Quality Guideline for Fuel Cell Vehicles*, June 2011. This specification has been harmonized to the extent possible with the draft international standard, *ISO/DIS 14687-2, Hydrogen Fuel – Product Specification – Part 2: Proton exchange membrane (PEM) fuel cell applications for road vehicles*, recently approved by the International Organization for Standardization (ISO).

The primary purpose of this specification is to ensure that the effects of possible fuel contaminants on fuel cell performance and durability in early commercial vehicles are acceptable. Modeling and analysis have shown that the impact on the cost of producing hydrogen fuel that complies with the specification is not significant. However, the costs of analyzing and verifying compliance with the specification are still under study. ASTM International has developed and is validating standardized methods to sample and analyze the presence of contaminants at the levels prescribed in the specification.

Additional fuel quality RD&D, fuel cell testing, operational data from fuel cell vehicles, improvements in the impurity tolerance of fuel cells, and advanced material storage options that are likely to introduce or impose different impurities may lead to revisions of these limits. Fuel Cell and Hydrogen Program RD&D planning will address hydrogen quality issues as they relate to cost and performance goals for each technology area— production, delivery, storage, fuel cells, and safety, codes and standards. Those issues and RD&D activities specific to each of these areas will be included in those sections of the RD&D Plan.

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Table C.1: Hydrogen Fuel Quality Specification				
Constituent	Chemical Formula	Limits ^e	Laboratory Test Methods to Consider and Under Development ^f	Minimum Analytical Detection Limit
Hydrogen fuel index	H ₂	>99.97%		
Total allowable non-hydrogen, non-helium, non-particulate constituent		100 $\mu\text{mol/mol}$		
Acceptable limit of each individual constituent				
Water ^a	H ₂ O	5 $\mu\text{mol/mol}$	ASTM D7653-10, ASTM D7649-10	0.12 $\mu\text{mol/mol}$
Total hydrocarbons ^b (C ₁ basis)		2 $\mu\text{mol/mol}$	ASTM D7675-11	0.1 $\mu\text{mol/mol}$
Oxygen	O ₂	5 $\mu\text{mol/mol}$	ASTM D7649-10	1 $\mu\text{mol/mol}$
Helium	He	300 $\mu\text{mol/mol}$	ASTM D1945-03	100 $\mu\text{mol/mol}$
Nitrogen, Argon	N ₂ , Ar	100 $\mu\text{mol/mol}$	ASTM D7649-10	5 $\mu\text{mol/mol}$
Carbon dioxide	CO ₂	2 $\mu\text{mol/mol}$	ASTM D7649-10, ASTM D7653-10	0.1 $\mu\text{mol/mol}$
Carbon monoxide	CO	0.2 $\mu\text{mol/mol}$	ASTM D7653-10	0.01 $\mu\text{mol/mol}$
Total sulfur ^c		0.004 $\mu\text{mol/mol}$	ASTM D7652-11	0.00002 $\mu\text{mol/mol}$
Formaldehyde	HCHO	0.01 $\mu\text{mol/mol}$	ASTM D7653-10	0.01 $\mu\text{mol/mol}$
Formic acid	HCOOH	0.2 $\mu\text{mol/mol}$	ASTM D7550-09, ASTM D7653-10	0.02 $\mu\text{mol/mol}$
Ammonia	NH ₃	0.1 $\mu\text{mol/mol}$	ASTM D7653-10	0.02 $\mu\text{mol/mol}$
Total halogenates ^d		0.05 $\mu\text{mol/mol}$	ASTM WK23815, WK34574	0.01 $\mu\text{mol/mol}$
Particulate Concentration		1 mg/kg	ASTM D7650-10, ASTM D7651-10	0.005 mg/kg

^a Due to water threshold level, the following constituents should not be found, however they should be tested for if there is a question on water content:

Sodium (Na⁺) @ <0.05 $\mu\text{mole/mole H}_2$ or <0.05 $\mu\text{g/liter}$

Potassium (K⁺) @ <0.05 $\mu\text{mole/mole H}_2$ or <0.08 $\mu\text{g/liter}$

or Potassium hydroxide (KOH) @ <0.05 $\mu\text{mole/mole H}_2$ or <0.12 $\mu\text{g/liter}$

^b Includes, for example, ethylene, propylene, acetylene, benzene, phenol (paraffins, olefins, aromatic compounds, alcohols, aldehydes). THC may exceed 2 micromoles per mole due only to the presence of methane, in which case the summation of methane, nitrogen and argon is not to exceed 100 ppm.

^c Includes, for example, hydrogen sulfide (H₂S), carbonyl sulfide (COS), carbon disulfide (CS₂) and mercaptans.

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- ^d Includes, for example, hydrogen bromide (HBr), hydrogen chloride (HCl), chlorine (Cl₂) and organic halides (R-X).
- ^e Limits are upper limits except for the hydrogen which is a lower limit. All limits are subject to revision after additional testing under operational conditions and improved standardized analytical procedures.
- ^f Gaseous sampling uses procedures in ASTM D7606-11