



SURFACE VEHICLE RECOMMENDED PRACTICE

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Recommended Practice for Compressed Natural Gas Vehicle Fuel

RATIONALE

This Recommended Practice sets minimum requirements for compressed natural gas as a surface vehicle fuel for vehicle, engine, and component durability, operating safety, and design performance over the breadth of vehicle applications intended to utilize this fuel.

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1. SCOPE

Compressed Natural Gas (CNG) is a practical automotive fuel, with advantages and disadvantages when compared to gasoline. Large quantities of natural gas are available in North America. It has a higher octane number rating, produces low exhaust emissions, no evaporative emissions and can cost less on an equivalent energy basis than other fuels. Natural gas is normally compressed from 20 684 to 24 821 kPa (3000 to 3600 psig) to increase its energy density thereby reducing its on-board vehicle storage volume for a given range and payload. CNG can also be made from liquefied natural gas by elevating its pressure and vaporizing it to a gas. Once converted it is referred to LCNG.

The properties of natural gas are influenced by: (1) source of supply i.e. field, composition or impurities; (2) the processing of natural gas by the production and transmission companies; (3) the regional gas supply, storage, and demand balancing done by distribution companies often in concert with pipeline companies to maintain uninterrupted service throughout the year, e.g., peak shaving with propane-air (see U.S. Bureau of Mines Publication 503); and (4) dispensing site maintenance characteristics i.e. filtration and drying.

The Coordinating Research Council (CRC) has published the results of a national compressed natural gas vehicle fuel survey. Information on the properties of distribution system natural gas and its variability has been included in Figure 1, 2, and 3, and can be found in CRC Report No. PC-2-12. Composition can vary hourly under certain operating conditions in certain areas of the country. Thus the data should generally be considered representative for the areas mentioned with due consideration for local variation.

Natural gases transported throughout the U. S. are not subject to uniform national standards. Under federal government rules covering interstate sales of natural gas, the U. S. Federal Energy Regulatory Commission (FERC) adjudicates tariffs, placing economic and technical requirements upon natural gases entering interstate commerce. In 2006, FERC issued a policy statement advising stakeholders that:

1. Only natural gas quality and interchangeability specifications contained in FERC-approved gas tariffs can be enforced;
2. Pipeline tariff provisions on gas quality and interchangeability need to be flexible to allow pipelines to balance safety and reliability concerns;
3. Pipelines and their customers should develop gas quality and interchangeability specifications based on technical requirements;

4. In negotiating technically-based solutions, pipelines and their customers are strongly encouraged to use the Natural Gas Council Plus (NGC+) Interim Guidelines...as a common reference point for resolving gas quality and interchangeability issues; and
5. To the extent pipelines and their customers cannot resolve disputes over gas quality and interchangeability, those disputes can be brought before FERC to be resolved on a case-by-case basis...¹

The NGC+ Interim Guidelines call for natural gas specifications that include:

1. A range of plus or minus 4% Wobbe number variation from local historical average gas, or alternatively, established adjustment or target gas for the service territory, subject to:
 - a. Maximum Wobbe number limit: 1400
 - b. Maximum higher heating value limit: 1110 Btu/scf
2. Additional composition maximum limits:
 - a. Maximum butanes+: 1.5 mole percent
 - b. Maximum total inerts: 4 mole percent
3. EXCEPTION: Service territories with demonstrated experience with supplies exceeding these Wobbe, higher heating value and/or compositional limits may continue to use supplies conforming to this experience as long as it does not unduly contribute to safety and utilization problems of end use equipment.²

While the Interim Guidelines provide only guidance for the setting of tariff limits on gas quality, experience has shown that in most cases the Wobbe and higher heating value limits are used in interstate tariffs. Since the bulk of U. S. sales of natural gas fall under FERC jurisdiction, this means that the Interim Guideline limits represent, in most cases, the limits that apply to natural gases received by distribution systems. Intrastate natural gas sales, by contrast, are not within FERC jurisdiction, but customers including utilities receiving gases from both intrastate and interstate sources, for practical purposes, generally receive natural gas that meets the Interim Guidelines.

The NGC+ Interim Guidelines address combustion issues associated with natural gases. Separately, FERC considered condensable hydrocarbons in response to a second paper from NGC+.³ No specific actions were recommended by FERC in response to the NGC+ recommendations from this report, which basically recommended translation of historical condensable hydrocarbon experience into more general phase diagram-depicted "cricondentherm hydrocarbon dew point" (CHDP) criteria for higher hydrocarbon mixtures. CHDP criteria help ensure that natural gases of various compositions remain in gaseous state at all operating pressures and all reasonable ambient temperatures.

Natural gas is comprised chiefly of methane (generally 88 to 96 mole percent) with the balance being a decreasing proportion of higher hydrocarbon alkanes such as ethane, propane, and butane. It can also contain nitrogen, water, carbon dioxide, oxygen, sulfur compounds and trace amounts of lubricating oil. At the retail outlet a warning agent, or odorant, is likely present in natural gas.

¹ Federal Energy Regulatory Commission, "Policy Statement on Provisions Governing Natural Gas Quality and Interchangeability in Interstate Natural Gas Pipeline Tariffs," Natural Gas Interchangeability, Docket No. PL04-3-000, June 15, 2006.

² NGC+ Interchangeability Work Group, "White Paper on Natural Gas Interchangeability and Non-Combustion End Use," February 28, 2005.

³ NGC+ Liquid Hydrocarbon Drop Out Work Group, "White Paper on Liquid Hydrocarbon Drop Out in Natural Gas Infrastructure," February 28, 2005.

Experience with natural gas vehicles has grown considerably. Fleet and ongoing in-use applications provide a foundation for characterizing gas composition factors that will help to understand gas quality effects on vehicle and overall performance and may cause fundamental operational problems for natural gas vehicles (NGVs). Water content and other corrosion precursors, heavier hydrocarbons, which may condense within the fuel container, particulate matter, oil, and energy content all need to be considered. Condensable hydrocarbons (liquid state) are also of concern in NGV equipment degradation.

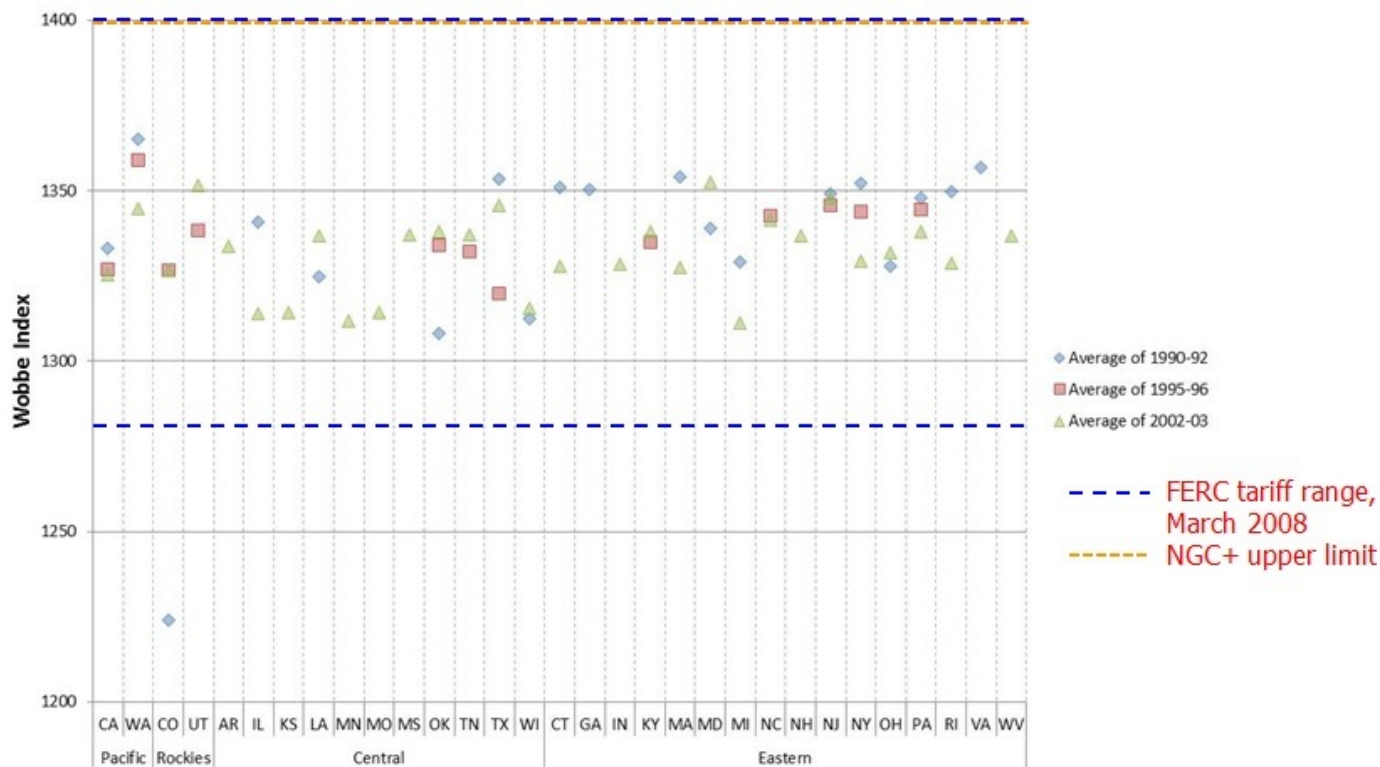


Figure 1 - Wobbe Index (Reference CRC report PC-2-12)

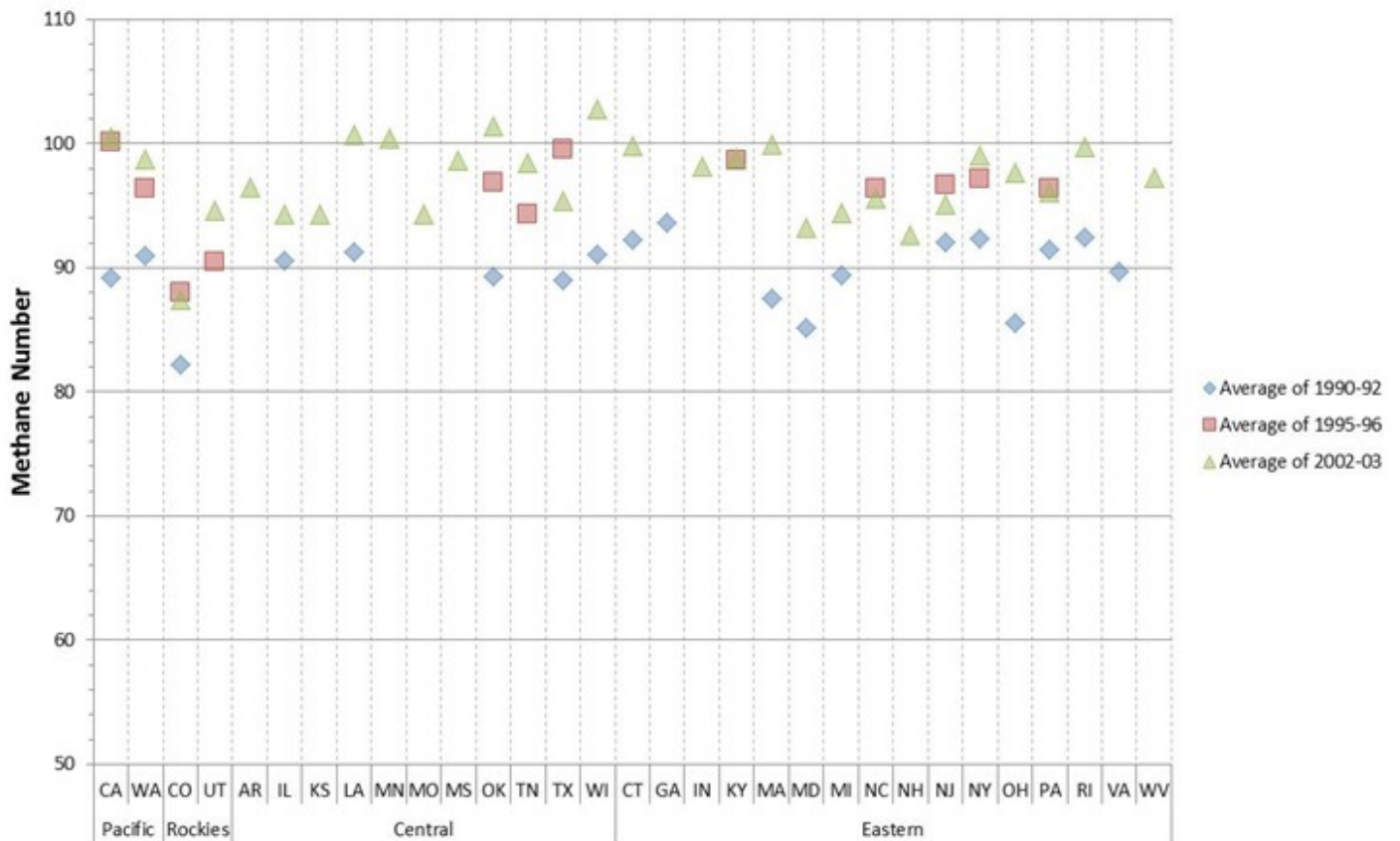


Figure 2 – Methane number (Reference CRC report PC-2-12)

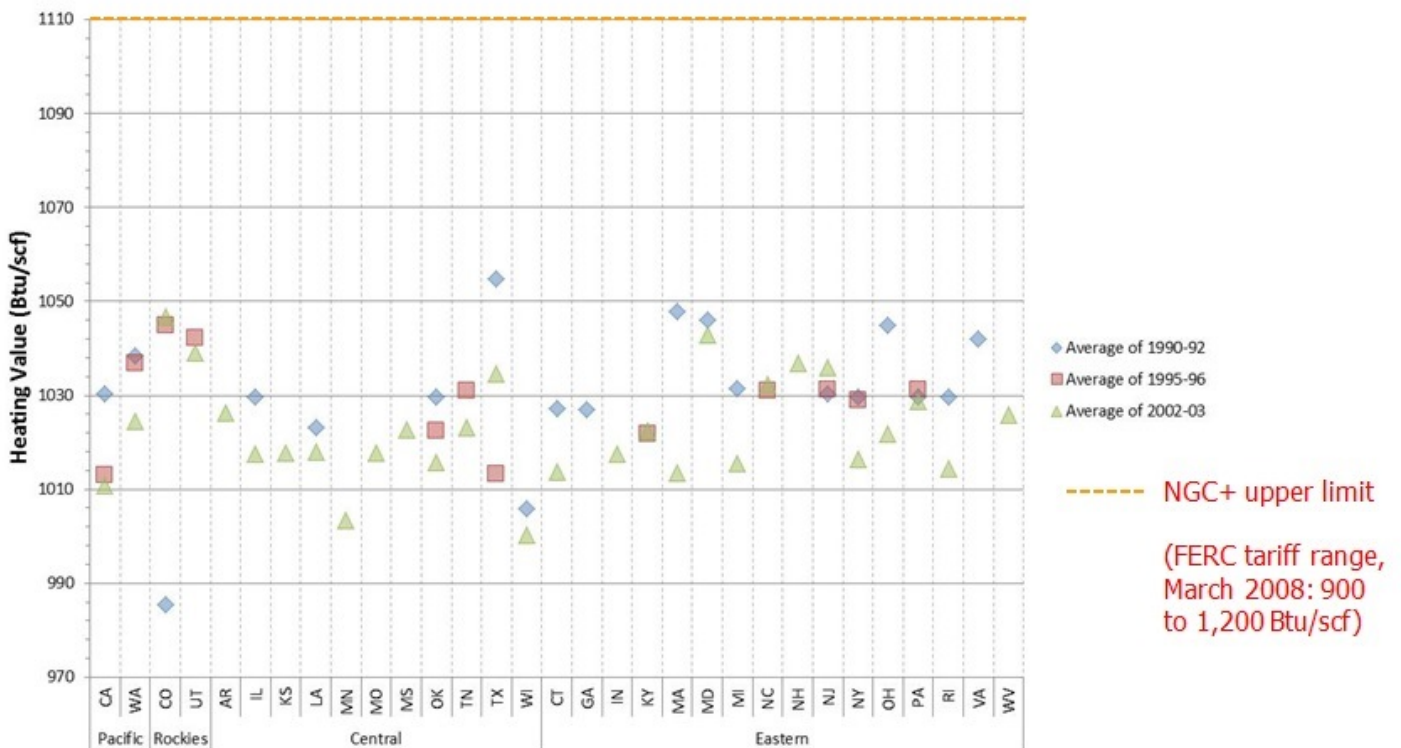


Figure 3 – Heating value (Reference CRC report PC-2-12)



Documents

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1.1 Purpose

The provisions contained in this SAE Recommended Practice are intended to provide minimum requirements for compressed natural gas fuel composition delivered to vehicle storage containers as measured at the station/vehicle interface. This document presents important physical and chemical characteristics of compressed natural gas vehicular fuel, and describes pertinent test methods for defining or evaluating these properties.

Requirements and guidance included are intended to permit satisfactory vehicle performance, operation and emission levels, and protect fuel system components from fuel-related malfunctions, and premature deterioration or failure. This document is intended as a guide and is subject to change to keep pace with experience and technical advances. See Appendix A for engine and vehicle manufacturer recommendations. For information on Liquefied Natural Gas fuel composition, See Recommended Practice SAE J2699, Liquefied Natural Gas Vehicle Fuel.

2. REFERENCES

2.1 Applicable Documents

The following publications form a part of this specification to the extent specified herein. Unless otherwise indicated, the latest issue of publications shall apply.

2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

King, S., "The Impact of Natural Gas Composition on Fuel Metering and Engine Operational Characteristics," SAE Technical Paper 920593, 1992, doi:10.4271/920593.

SAE J2699 Liquefied Natural Gas Vehicle Fuel

2.1.2 ASTM Publications

Available from ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959, Tel: 610-832-9585, www.astm.org

D1142	Standard Test Method for Water Vapor Content of Gaseous Fuels by Measurement of Dew-Point Temperature
D1945	Standard Test Method for Analysis of Natural Gas by Gas Chromatography
D2650	Standard Test Method for Chemical Composition of Gases By Mass Spectrometry
D3588	Standard Practice for Calculating Heat Value, Compressibility Factor, and Relative Density of Gaseous Fuels
D4084-94	Standard Test Method for Analysis of Hydrogen Sulfide in Gaseous Fuels (Lead Acetate Reaction Rate Method)
D4810	Standard Test Method for Hydrogen Sulfide in Natural Gas Using Length-of-Stain Detector Tubes
D5454	Standard Test Method for Water Vapor Content of Gaseous Fuels Using Electronic Moisture Analyzers
D5504	Standard Test Method for Determination of Sulfur Compounds in natural gas and Gaseous Fuels by Gas Chromatography and Chemiluminescence
D6228	Standard Test Method for Determination of Sulfur Compounds in Natural Gas and Gaseous Fuels by Gas Chromatography and Flame Photometric Detection
D6273	Standard Test Method for Natural Gas Odor Intensity

2.1.3 Gas Technology Institute Publications

Available from the Gas Technology Institute, 1700 S. Mount Prospect Road, Des Plaines, IL 60018, 847-768-0500, www.gastechnology.org

Natural Gas Vehicle Technology and Fuel Performance Evaluation Program, Oreste Bevilacqua, GTI Report 97/0184, 6/97

NGV Fueling Station Compressor Oil Carryover Measurement and Control, M. Czachorski et al., GRI-95/0483, 2/96

Validation Testing of a Gravimetric Method to Measure CNG Compressor Oil Carryover, M Czachorski and R. Kina, GRI-98/0228, 6/98

Variability of Natural Gas Composition in Select Major Metropolitan Areas of the United States, W. E. Liss et al., GRI-92/0123, 3/92

2.1.4 National Oceanic and Atmospheric Administration Publications

Available from National Oceanic and Atmospheric Administration, U.S. Department of Commerce, 14th Street & Constitution Avenue, NW, Room 6217, Washington, DC 20230, Phone: (202) 482-6090, www.noaa.gov

Comparative Climatic Data for the United States through 1991 (or a more recent addition), (<http://www.ncdc.noaa.gov/oa/climate/normal/usnormals.html>)

Climatology of the U. S. No. 20: Climatic Summaries for Selected Sites, 1951-80, <http://www.ncdc.noaa.gov/oa/climate/climatedata.html>

2.1.5 NFPA Publication

Available from the National Fire Protection Association, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101, 1-800-344-3555 or <http://catalog.nfpa.org>

NFPA 52 Vehicular Gaseous Fuel Systems Code

2.1.6 State of California Publication

Available on the web at <http://ccr.oal.ca.gov/>

Specifications for Compressed Natural Gas, California Air Resources Board, Title 13, Division 3, Chapter 5, Article 3, Section 2292.5 of the California Code of Regulations

2.1.7 U.S. Environmental Protection Agency Publication

Available on the web at <http://www.ecfr.gov>

Test Fuel Specifications for Natural Gas, 40 CFR Part 1065.715

2.1.8 U.S. Department of the Interior Publication

Available from U.S. Department of the Interior, 1849 C St., NW, Washington, DC 20240, www.doi.gov

Limits of Flammability of Gases and Vapors, Bureau of Mines Publication 503, C.F. Coward & G.W. Jones, 1952.