

Testing of North American Certified Appliances for Operation on Blends of Natural Gas and Hydrogen

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Benefits and Relevance

North American natural gas utilities are envisioning introduction of “renewable natural gas” (RNG) into the North American natural gas system, including hydrogen-enriched gases from “power-to-gas” (PtG) projects with between 5% and 15% hydrogen (by volume fraction). To date, design certification test performance to North American consensus standards for such mixtures is unknown, and leakage potential compared to allowable leak rates is unstudied.

The project would provide initial verification of safe use of hydrogen-enriched gases under current standards if not problems identified. Alternatively, the project might identify needs for changes to the standards, including perhaps at a minimum, changes to test gases currently used in performance testing for certification.

Project Description

Objective: Conduct **an exploratory study** of appliance and equipment performance responses to hydrogen-enriched gases based upon:

- North American consensus standards (ANSI-recognized Z21.xx) performance tests
- Appliance efficiency tests based on North American-promulgated test procedures
- Regulated atmospheric emissions performance (e.g. NO_x)
- Qualitative field procedures used to evaluate appliance combustion performance
- Specially-designed leakage tests to determine leakage relevant to hydrogen-enriched gases.



Research Project Submission

Proposal Number	RP-nnnn
Topic	Appliance and Equipment Performance Testing with Hydrogen Enriched Natural Gases
Submitter(s)	Ted A. Williams, American Gas Association
Date	March 12, 2018
Estimated Cost	\$100,000 USD/\$130,000 CAD
Estimated Duration	9 months
Category (Macro or Micro)	Macro
Problem (One or two sentences addressing the need and its urgency)	North American natural gas utilities are envisioning introduction of "renewable natural gas" (RNG) into the North American natural gas system, including hydrogen-enriched gases with between 5% and 15% hydrogen (by volume fraction). To date, design certification test performance to North American consensus standards for such mixtures is unknown, and leakage potential compared to allowable leak rates is unstudied.
Objective (One or two sentences addressing the expected deliverable)	The objective of the work is to conduct an exploratory study of appliance and equipment performance responses to hydrogen-enriched gases based on North American consensus standards performance tests, appliance efficiency tests based on North American-promulgated test procedures, regulated atmospheric emissions performance, qualitative field procedures used to evaluate appliance combustion performance, and specially-designed leakage tests to determine leakage relevant to hydrogen-enriched gases. Results would be presented to the Z21/83 and CSA Gas committees for potential future consideration to modification of the standards to cover hydrogen-enriched gases.
Project Description (Two paragraphs or more to explain how the research will be conducted)	<p>The project would involve the following proposed task:</p> <p>Task 1: Selection of Appliances for Performance and Leakage Testing: It is envisioned that, for this exploratory program, two central furnaces (Categories I and IV), two central boilers (Categories I and IV), four residential storage water heaters (two "ultra-low NOx" category), two cooking appliances (with top burners and ovens), and two vented space heaters would be selected. Appliance manufacturers would be solicited to provide test units.</p> <p>Task 2: Selection of Equipment for Performance and Leakage Tests: It is envisioned that four types of manual valves and four appliance controls would be tested for performance and leakage.</p> <p>Task 3: Leakage Tests: Appliances and equipment would be tested for leakage under static standby and operating modes in a sealed chamber for measuring leakage to test gases (based upon mass transfer) and odorant (based upon gas detection) for Test Gas A and mixtures of Test Gas A with 5%, 10%, and 15% hydrogen (by volume fraction). Testing would document leakage of natural gas, hydrogen, and odorant.</p> <p>Task 4: Performance Tests: Appliances would be tested according to Standards for Safety performance as called for in the relevant standards, energy efficiency based on promulgated energy efficiency test procedures, qualitative observation of combustion behavior, and NOx emissions performance (ultra-low-NOx products only).</p> <p>Task 5: Reporting and Presentation: Results would be presented to the Z21/83 and CSA Gas committees for information and potential action.</p>

Project Presentation to Z21/Z83 Technical Committee, October 16, 2018



- **Emphasis upon Project Status And Solicitation of Participation**
- **Explanation of the “Exploratory” Nature of the Project**
- **Pointing to Z21/Z83 Technical Committee as the Principal “Client” of the Work**
- **Review of Project Timeline.**

Principal “Drivers” for Testing

- Public Announcements from Large Natural Gas LDCs in the U. S. and Canada to Introduce PtG-Generated Hydrogen
- Near-Term Objectives (and some regulatory commitments) to Introduce 5% Blends
- Some Longer-Term Objectives to Introduce 15% Blends
- North American Supplier Associations’ “Literature Review” of Blending Focus on Operational Issues; No Appliance Manufacturer Engagement
- Publicly-Available Research Focus on Research Burners, Appliance Burners, and Some European Appliances.

Relevant Past AGA Research Involvement



By **Howard B. Levinsky,**
Gasunie Engineering and Technology,
Groningen, The Netherlands

Consumer Appliance Population Raises Issues In Gas Interchangeability Testing

LNG from throughout the world is being introduced into the U.S. market while at the same time pipeline gas from Russia and LNG from the Middle East are becoming increasingly important for Western Europe. The change in geographical origin of

on the current insights into the subject, and report on research being performed.

Whereas the emphasis of this discussion is the situation in the U.S., we shall also refer to European information, where relevant. In addition, since discussion in the U.S. is cen-

Increased soot formation can lead to soot deposition in the heat exchanger, resulting in lower aeration, further increasing soot formation, etc.

For the burner, rust from the heat exchanger falling onto the burner surface and “linting”^[3],

Testimonial on Gasunie Engineering & Technology Project Work for American Gas Association (USA):

“Technical Support on Interchangeability Testing of Natural Gas Appliances”

**Dr. Howard Levinsky, Senior Scientist,
Combustion Research, Gasunie and
Professor of Combustion Science, University of Groningen, Principal
Investigator**

Research and Analysis Impacts

White Paper on Natural Gas Interchangeability and
Non-Combustion End Use

NGC+ Interchangeability Work Group
February 28, 2005*

- **AGA-Led Work Group**
- **“Interim Guidelines”
for Gas
Interchangeability**

- **FERC Policy
Statement on Gas
Interchangeability**
- **Recommendation to
Use the “Interim
Guidelines**

UNITED STATES OF AMERICA
FEDERAL ENERGY REGULATORY COMMISSION

Before Commissioners: Joseph T. Kelliher, Chairman;
Nora Mead Brownell, and Sudeen G. Kelly.

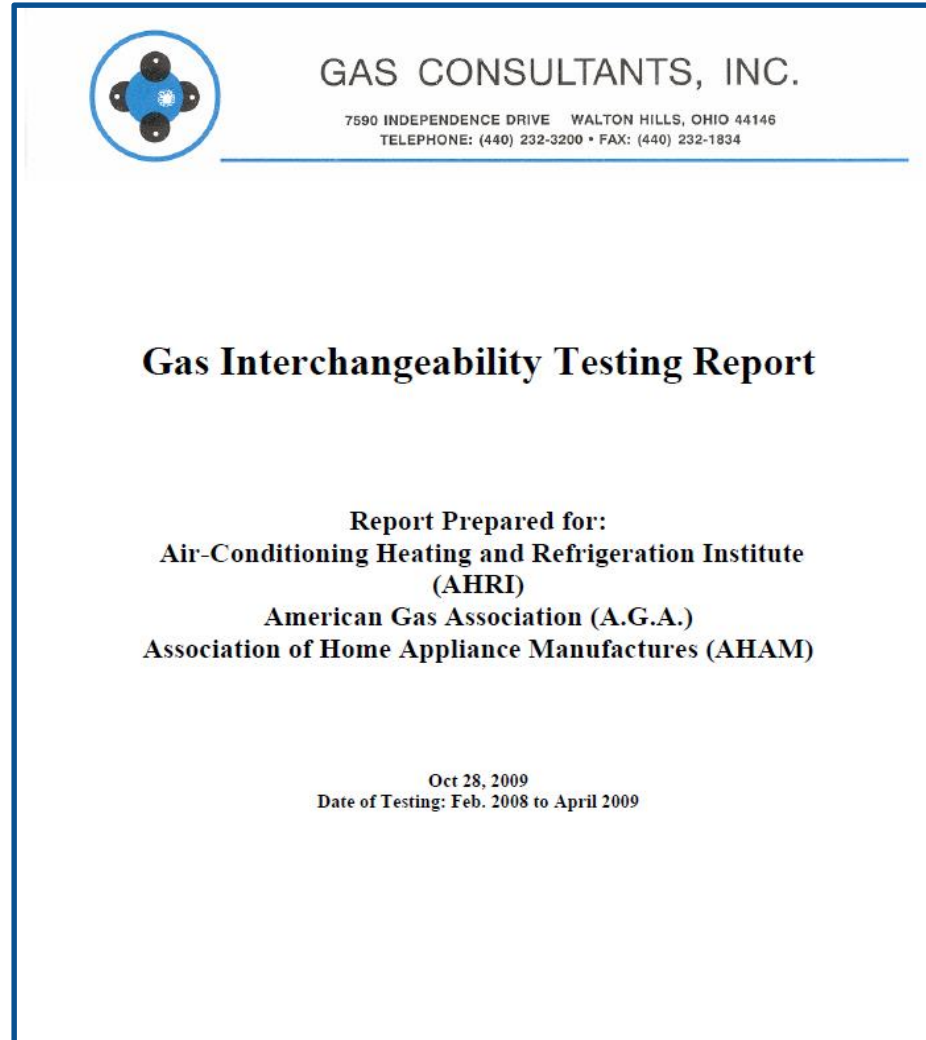
Natural Gas Interchangeability

Docket No. PL04-3-000

POLICY STATEMENT ON PROVISIONS GOVERNING NATURAL GAS QUALITY
AND INTERCHANGEABILITY IN INTERSTATE NATURAL GAS PIPELINE
COMPANY TARIFFS

(Issued June 15, 2006)

Project Model for Hydrogen Blend Testing



- **Appliance Manufacturer-Driven with Gas Supplier Participation**
- **Large Sample of Test Units and Wide Distribution of Appliance Types – 86 Units Across 10 Types**
- **Testing on Broad Ranges of Gas Compositions (Representing Imported LNGs) – Four “LNGs,” Plus Baseline Gas**
- **Use of Z21/Z83 Performance Tests and Performance Criteria**
- **More Exhaustive Testing and Technical Working Group Oversight; *Not “Exploratory.”***

Project Sponsors

- **CSA Group – Contractual Lead**
- **AHRI**
- **AGA**
- **(AHAM and HPBA invited but not participating).**

**Testing Organization – Appliance Engineering, Inc.,
Twinsburg, Ohio (formerly Gas Consultants, Inc.)**

Work Scope

- **Task 1: Literature Review and Preliminary Analysis**
- **Task 2: Appliance Verification Testing Using Line Natural Gas**
- **Task 3: Appliance Setup for Performance Tests**
- **Task 4: Appliance Performance Testing**
- **Task 5: Leakage Testing**
- **Task 6: Reporting.**

Manufacturer-Supplied Appliance Units for Testing

- **Two (2) Category I and Two (2) Category IV Furnaces Rated at 80 kBtuh**
- **Two (2) Category I and Two (2) Category IV Boilers Rated at 100 kBtuh**
- **Two (2) Ultra-Low NO_x and Two (2) Standard Storage Water Heaters Rated at 40 kBtuh**
- **Two (2) Vented Space Heaters Rated at 40 kBtuh.**

Task 1 Details

Literature Review and Preliminary Analysis

- **Collection and Review of Relevant Standardized Test Methods, Focusing Upon Non-Traditional Tests (i.e., leakage) from Europe, South Korea, and Australia**
- **Computation of Heating Values and Flue Gas Dewpoints for H₂ Blends of 5% and 15% in pure CH₄ (testing based upon certified test gases; pure methane used in blends to avoid impacts from variable line gas)**
- **Development of Flue Loss and Excess Air Predictions for Ultimate CO₂ Equations (these will be altered by volume percent H₂ blends).**

$$CO_{AFppm} = \left(\frac{UCO_2}{CO_2} \right) \times CO$$

Task 2 Details

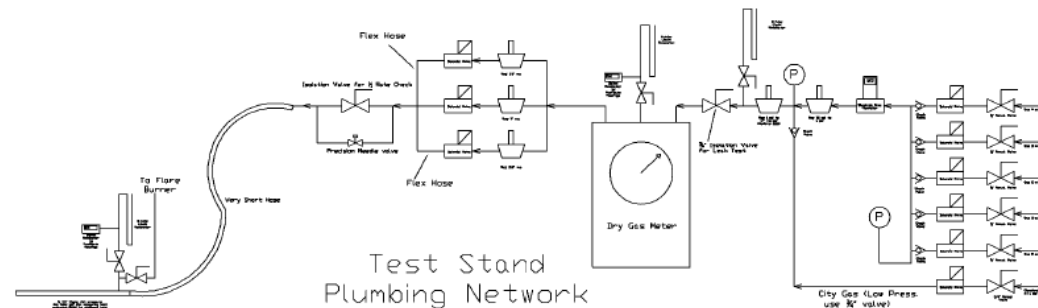
Appliance Verification Testing Using Line Natural Gas

- **Name Plate Rate (using Z21.xx performance criteria for “Test Gas A”)**
- **Ignition Evaluation**
- **Burner Operating Characteristics (B.O.C.) – Full Rate Only**
- **Carbon Monoxide Emissions**
- **NO_x Emissions (all vented test units).**

Task 3 Details

Appliance Setup for Performance Tests

- **Standard-Documented Protocols – Z21.xx “Performance” Tests, Federal Efficiency Standards, SCAAQD NO_x Protocol, Australian and South Korean Leakage Methods**
- **Additional Thermocouple Coverage in Appliance for Flue Path and Critical Components**
- **Thermocouple Coverage of Vents and Utilities.**



Task 4 Details

Appliance Performance Testing

- **Challenges:**
 - **Time Criticality for Establishing Stable Performance Data**
 - **Sequencing of Tests**
 - **Steady State Conditions Versus Start Ups**
 - **Conservation of Test Gases.**

Task 5 Details

Leakage Testing

- **Testing on Fuel Gases**
- **Use of International Standards: EN203-1, South Korean Standard AB338, and Australian Standard AS/NZS 4563**
- **Capping of Gas Train Assemblies (e.g., orifice blanks)**
- **Pressurizing Fuel System at Operating Pressure/Measuring Pressure Decay**
- **Emphasis Upon Safety.**

Task 6

Project Deliverables

- **Appliance Engineering, Inc. Final Report**
- **Sponsor Presentations – Various Venues**
- **International Gas Research Conference (IGRC) 2020 Paper, Muscat, Oman.**

Project Timeline

- **Project Initiation – June 15, 2019**
- **Testing Completion – March, 2020 (assuming original nine (9) month duration)**
- **Final Deliverables – April 2020.**

Thank You!

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