

Fuel Quality Initiatives

Propane Engine Fuel Summit

November 13, 2008

Greg Kerr

Propane Education &
Research Council

Mike Ross

Southwest Research Institute



PROPANE
EXCEPTIONAL ENERGY®

Program Outline

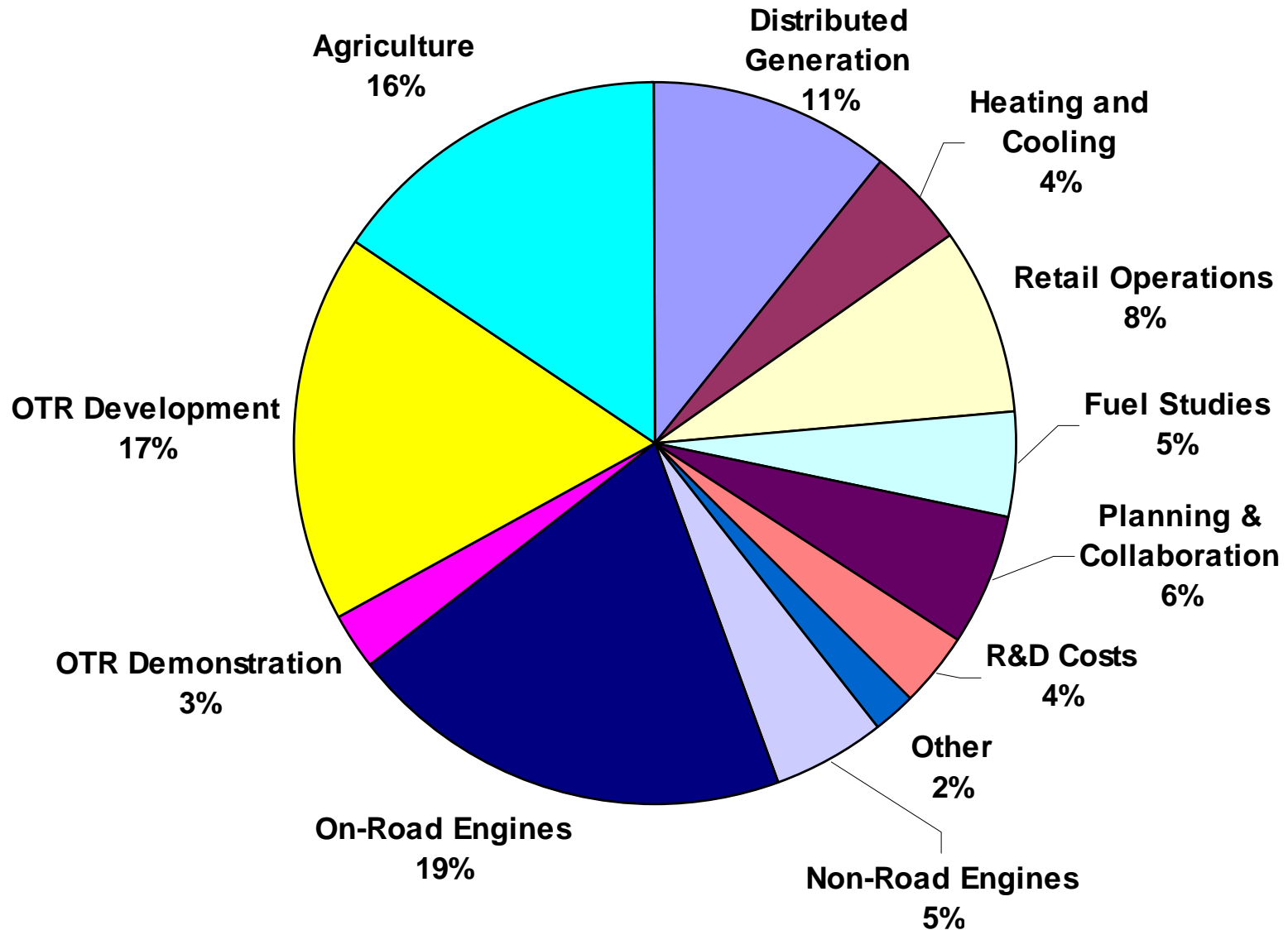
- Introduction
- Overview PERC fuel quality initiatives
- SwRI programs
 - Forklift
 - Deposit formation and mitigation

Introduction

- Majority fuel high quality
 - Small % fuel affects 15%
- Sensitive markets
 - Newer engines
 - Fuel cells
- Council adopted plan 2003
 - 40+ member Fuel Quality Working Group
 - Focus on end use



Approved R&D Grants



PERC Fuel Quality Projects

Survey

- 11354 LP Gas Surveys

Detection

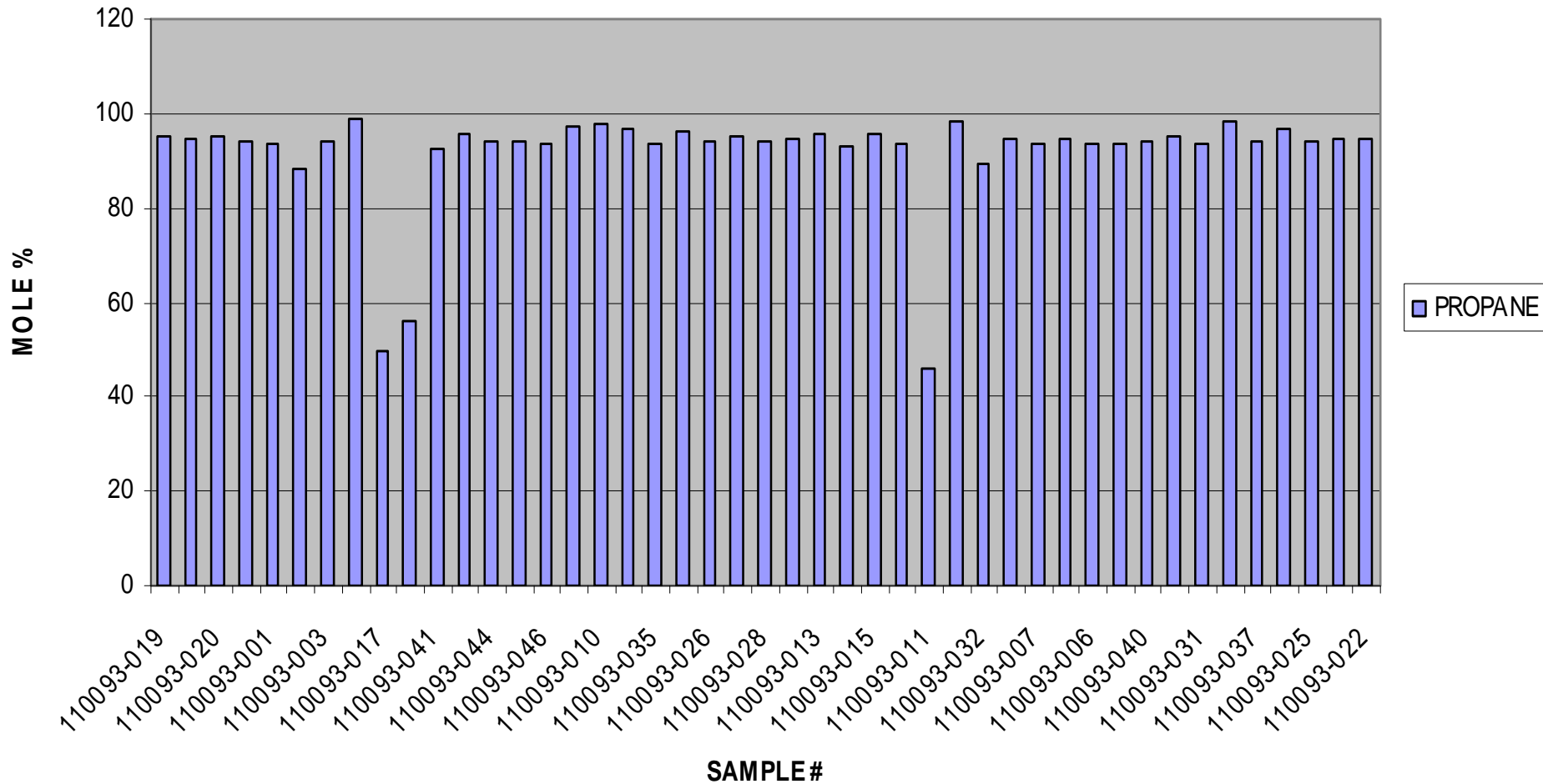
- 11296 Handheld / Portable Devices
- 12117 Gas Detection Tubes and In-Line Filtration Sampling

Water

- 11353 Water and Solid Contaminant Control
- 11992 Proper Use of Methanol
- 12470 Handheld Water Detector Design

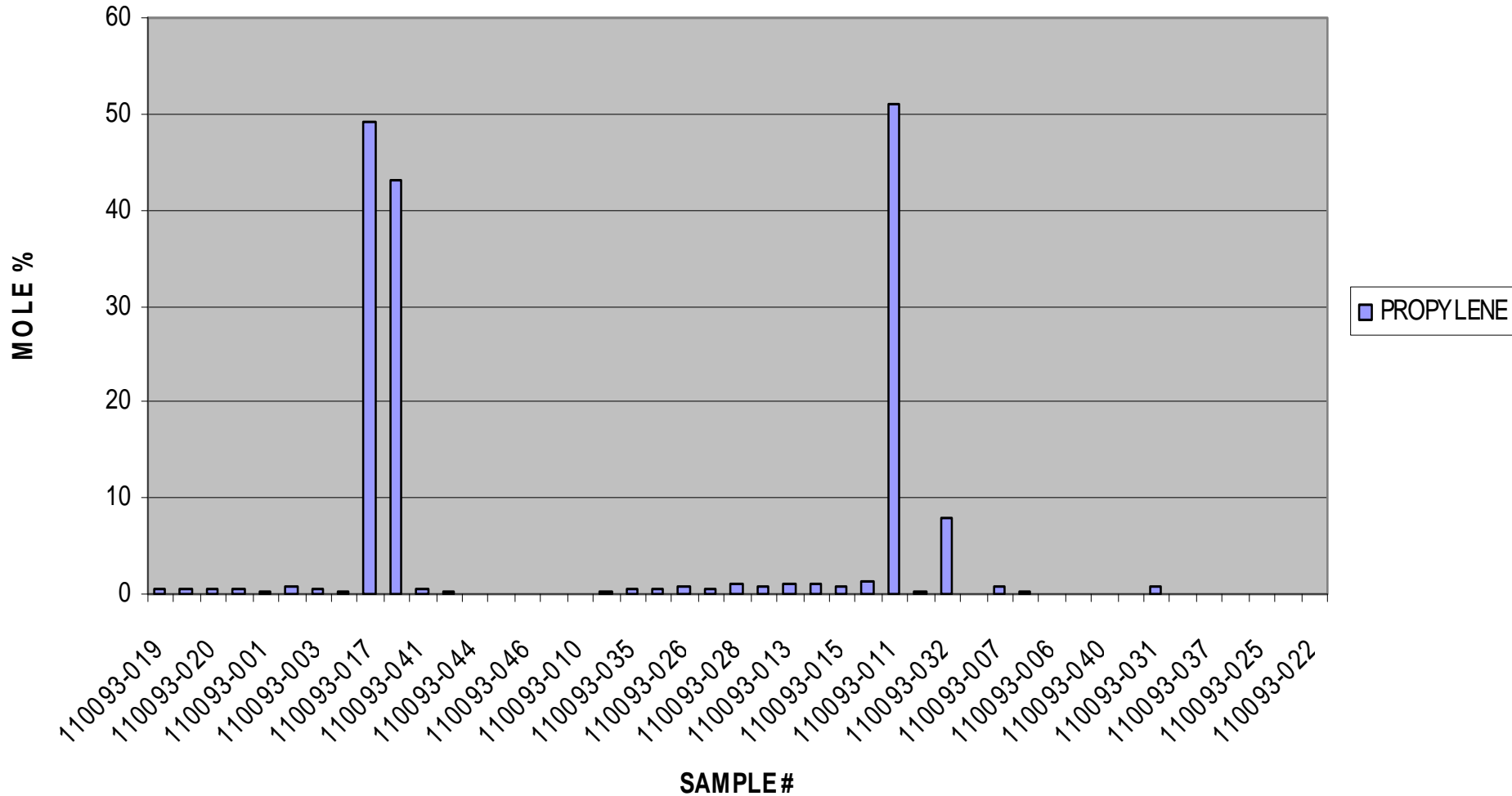
Propane

PROPANE



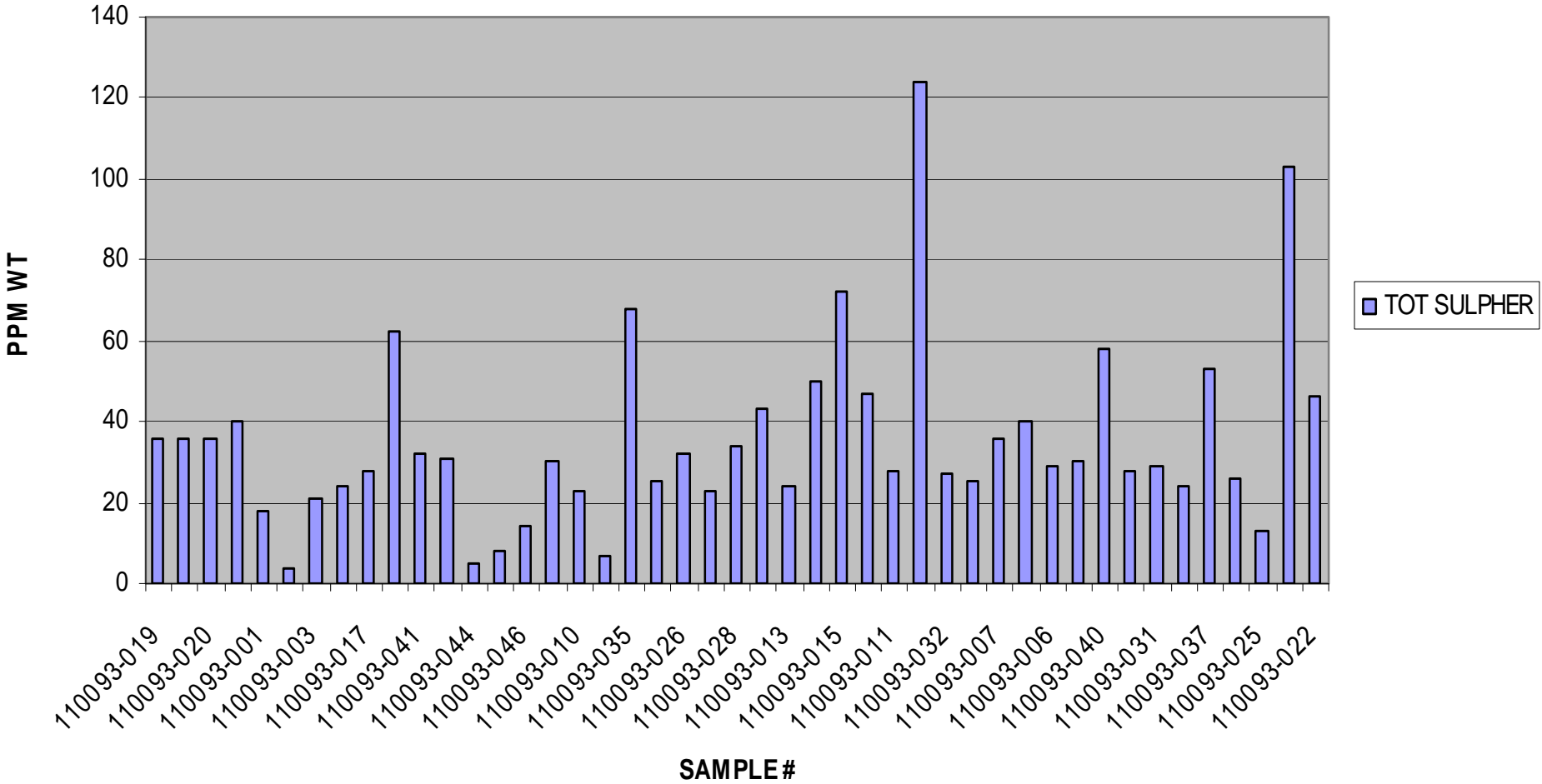
Propylene

PROPYLENE



Total Sulfur

TOT SULPHER



PERC Fuel Quality Projects

Survey

- 11354 LP Gas Surveys

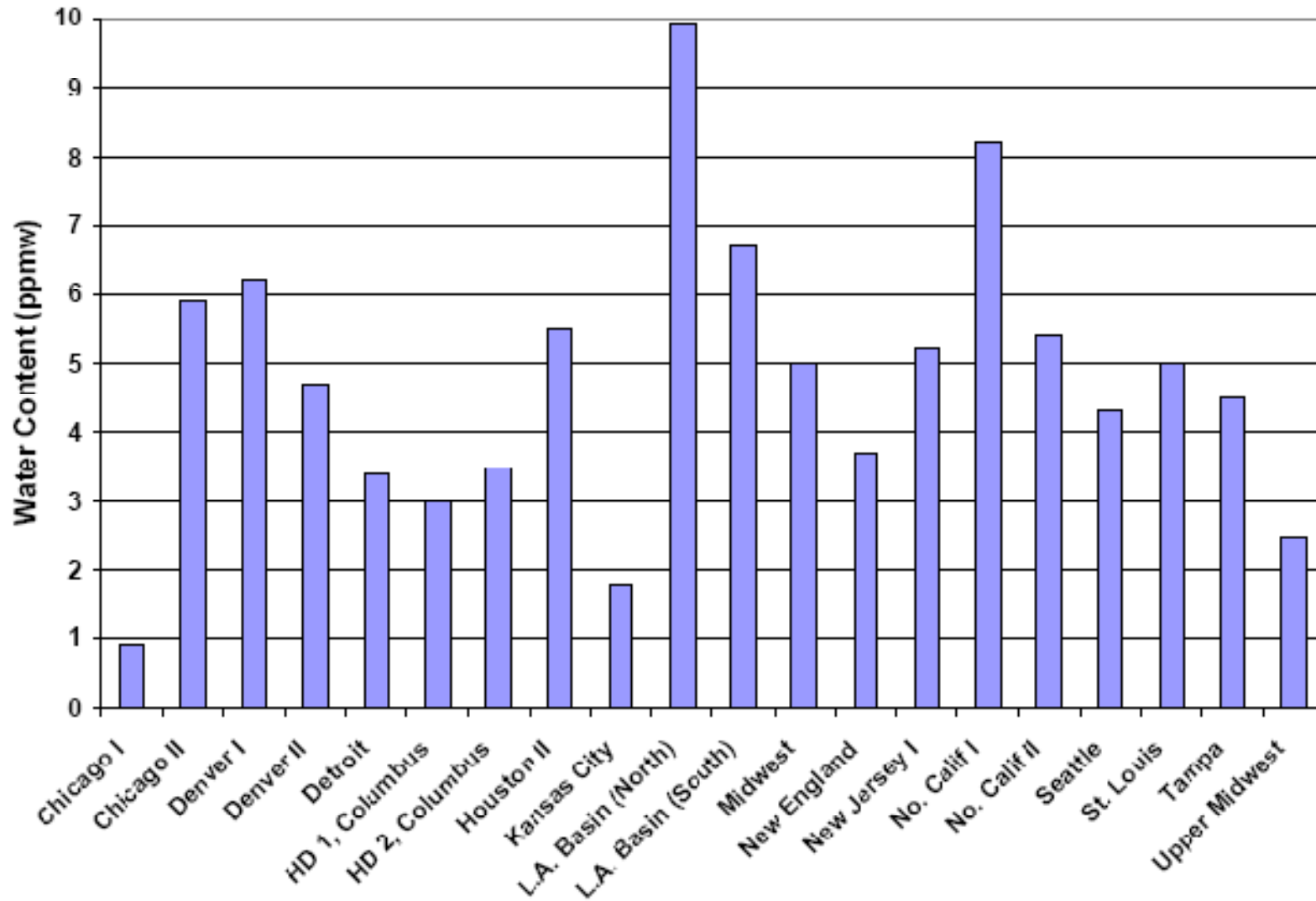
Detection

- 11296 Handheld / Portable Devices
- 12117 Gas Detection Tubes and In-Line Filtration Sampling

Water

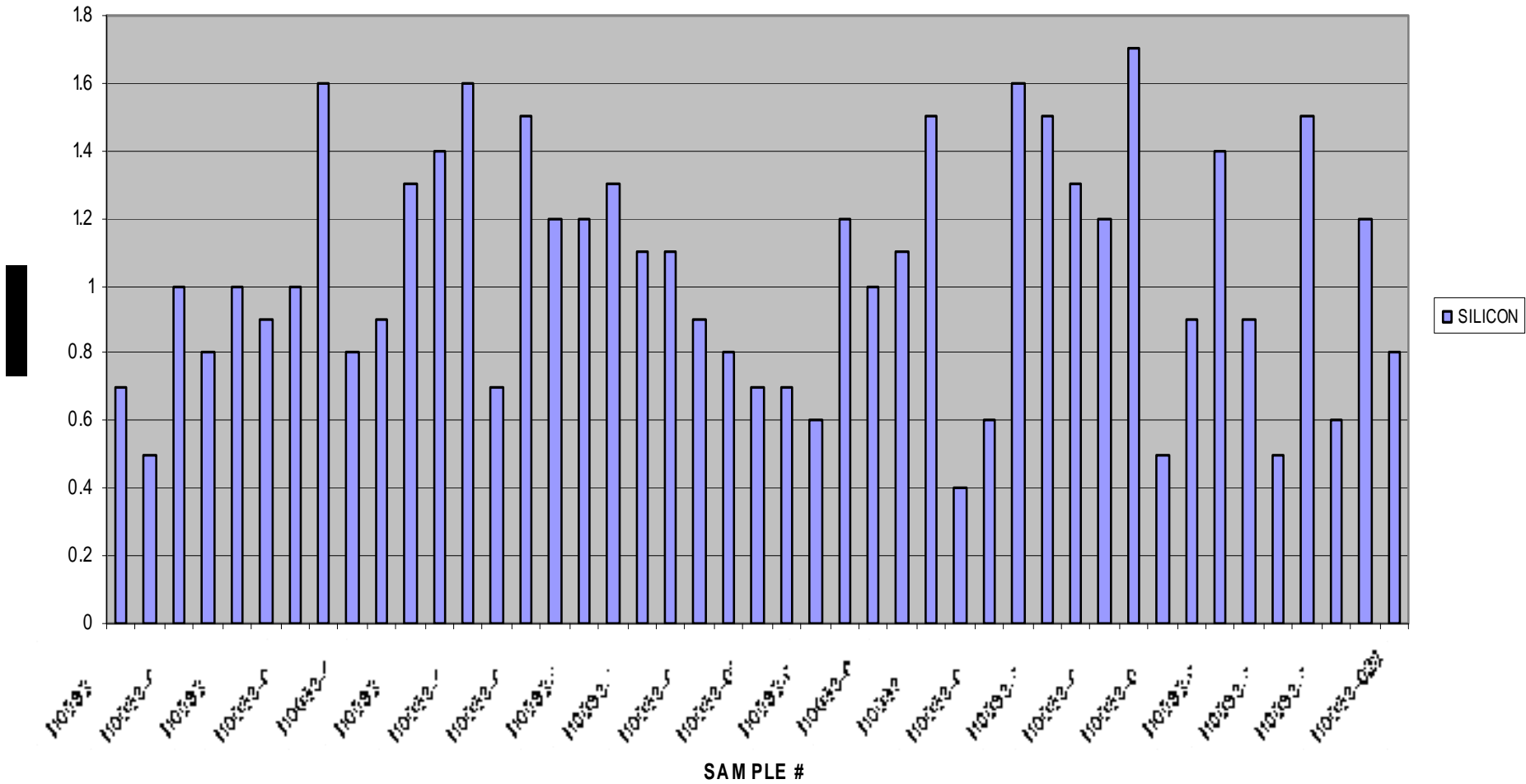
- 11353 Water and Solid Contaminant Control
- 11992 Proper Use of Methanol
- 12470 Handheld Water Detector Design

Water



Silicon

SILICON



PERC Fuel Quality Projects

Survey

- 11354 LP Gas Surveys

Detection

- 11296 Handheld / Portable Devices
- 12117 Gas Detection Tubes and In-Line Filtration Sampling

Water

- 11353 Water and Solid Contaminant Control
- 11992 Proper Use of Methanol
- 12470 Handheld Water Detector Design

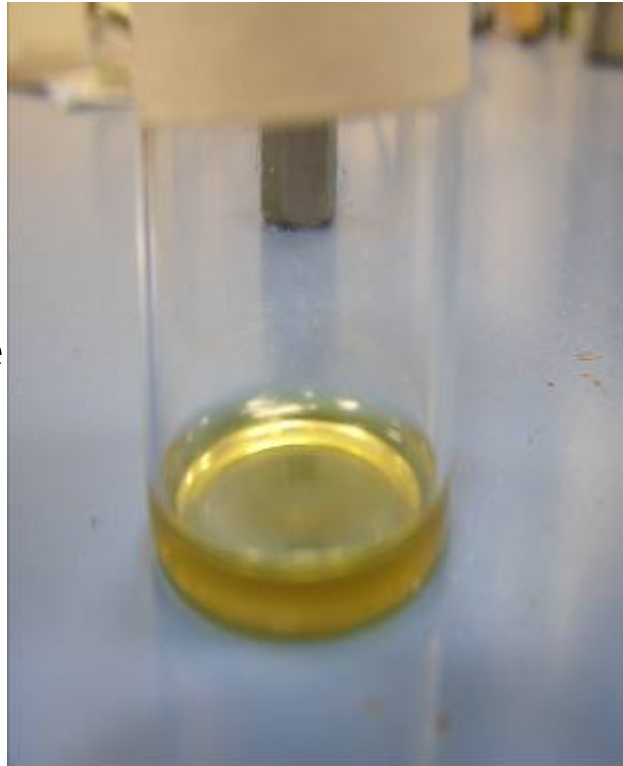
PERC Fuel Quality Projects

Contaminants

- 11649 Bulk Plant Contaminant Remediation
- 11297 Hose Conditioning
- 10951 LPG Fuel Systems and Fuel Composition Effects
- 12116 LPG Deposits and Mitigation Methods

11297 Hose Conditioning

- Plasticizers leach from hose
- Leaching rate decreases over time
- Hose can be conditioned
- Consider using nylon or Teflon lined hoses



PERC Fuel Quality Projects

Contaminants

- 11649 Bulk Plant Contaminant Remediation
- 11297 Hose Conditioning
- 10951 LPG Fuel Systems and Fuel Composition Effects
- 12116 LPG Deposits and Mitigation Methods

For project fact sheets and reports

Web: <http://www.propaneresearch.com>
"fuel studies"

Email: greg.kerr@propanecouncil.org



Southwest
Research
Institute®



Propane Fuel Quality Research

Propane Engine Fuel Summit

November 13, 2008

Michael G. Ross
Southwest Research Institute



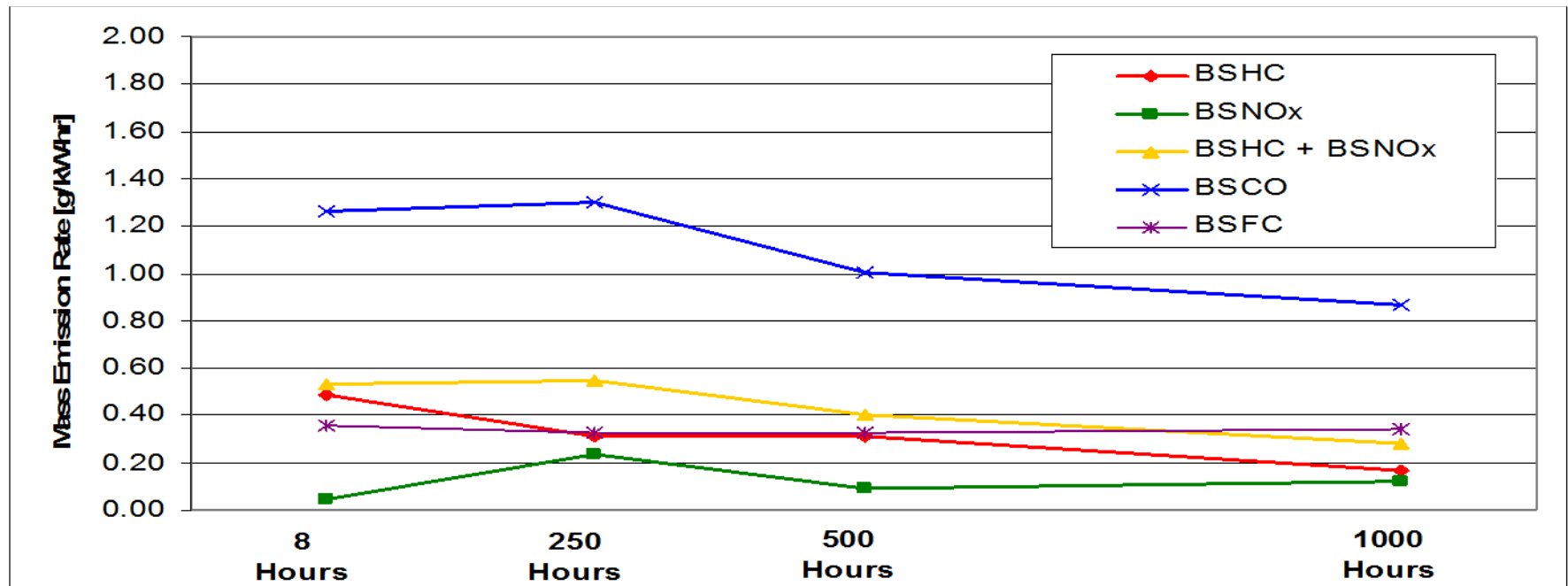
PROPANE
EXCEPTIONAL ENERGY®

Effect of Fuel Quality on Emissions (PERC docket 10951)

- Tests on 2.0L forklift engines equipped with feedback fuel control and 3-way catalyst
- Studied the effect of fuel quality on emissions
 - Propylene
 - Sulfur
 - Heavy Ends
 - Additives

Effect of Propylene on Emissions

- Tested up to 30% propylene on a 2.0L forklift engine equipped with closed-loop fuel control and a 3-way catalyst
- No appreciable effect on emissions



Effect of Sulfur on Emissions

- Objective: evaluate potential for catalyst poisoning due to exposure to excessive sulfur

- Approach: age catalyst on Nissan H20 engine for 500 hours with 160 ppm S fuel

Commercial propane limit	185 ppm
--------------------------	---------

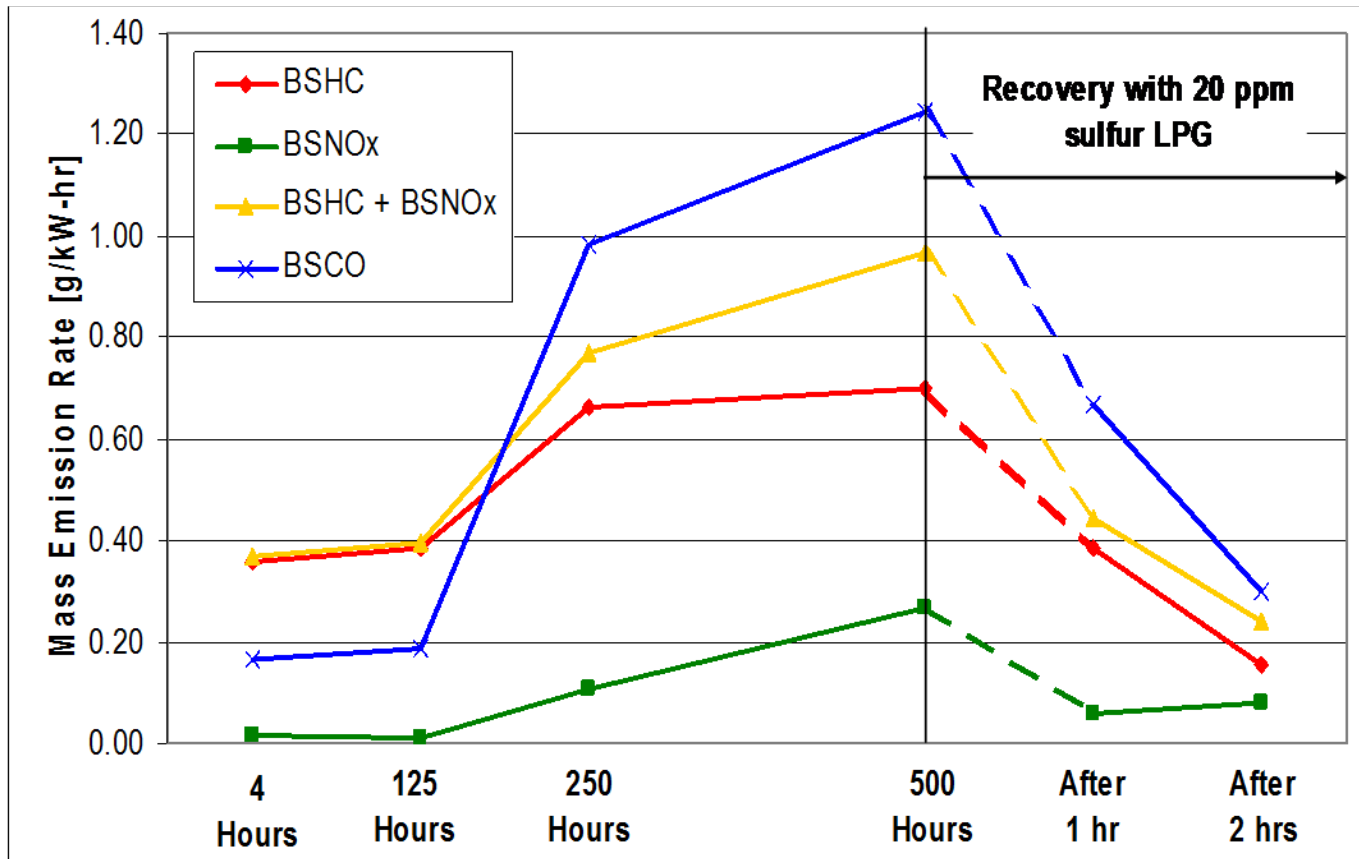
HD-5 limit	123 ppm
------------	---------

"HD-10" limit	80 ppm
---------------	--------

Typical level	20-30 ppm
---------------	-----------

Effect of Sulfur on Emissions

- Emission deteriorated with 160 ppm sulfur
- Emissions recovered with 20 ppm sulfur

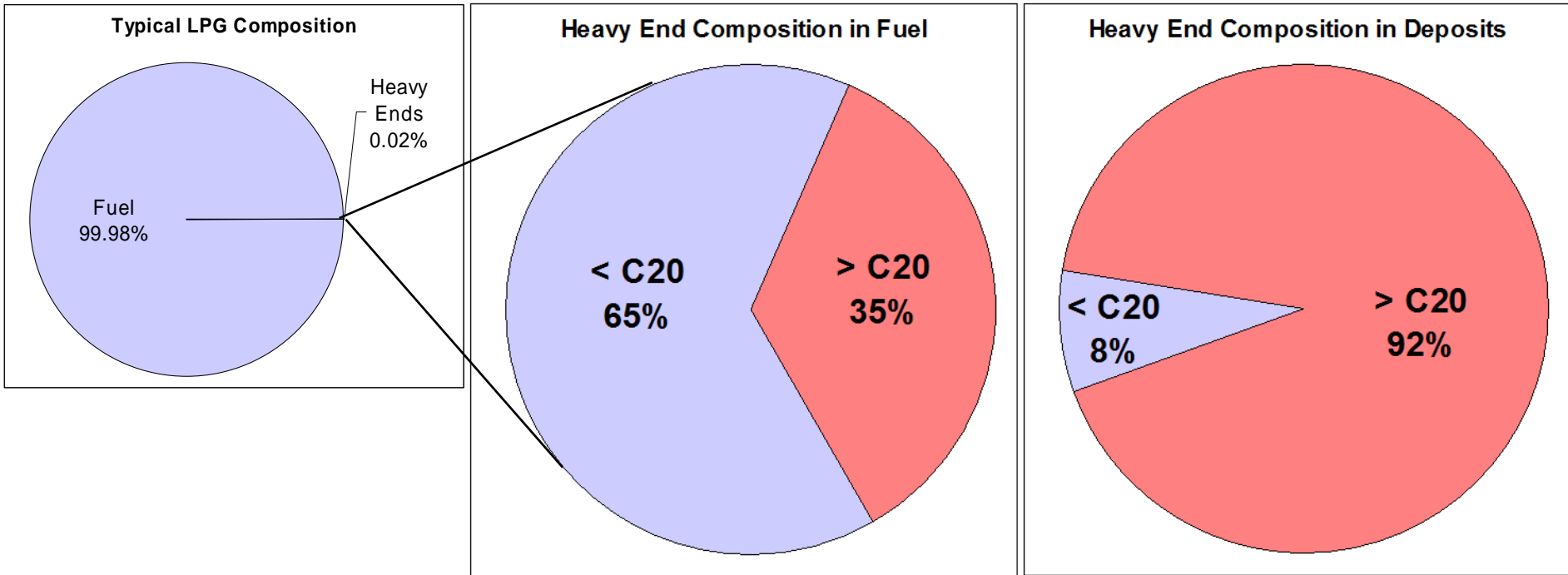


Effect of Heavy Ends on Emissions

- Engines were tested with various heavy-end compositions
- Vaporizers and mixers tolerated considerable deposits without emissions performance degradation
- Phthalates appeared in all deposits, but constituted less than 1% of most deposits
- Heavy ends over C20 caused deposits



Heavy End Composition



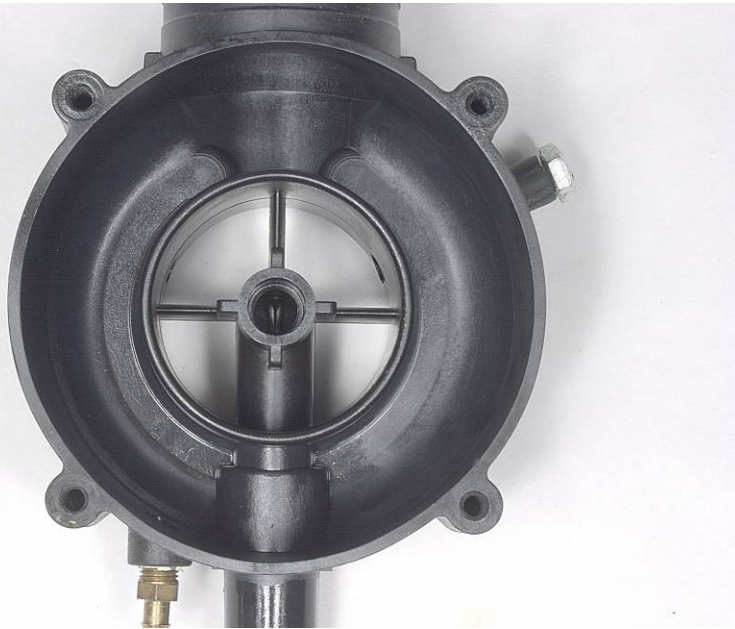
- Only the heavier components (>C20) tend to form deposits
- The lighter components (<C20) appear to be carried through combustion

Effect of Additives

- Additives may either increase or decrease deposits, depending on the engine component in question
- Additive kept the fuel system clean, but intake manifold and intake valve deposits increased



Impact of Additive on Deposits



**Mixer bowl with
Additive**

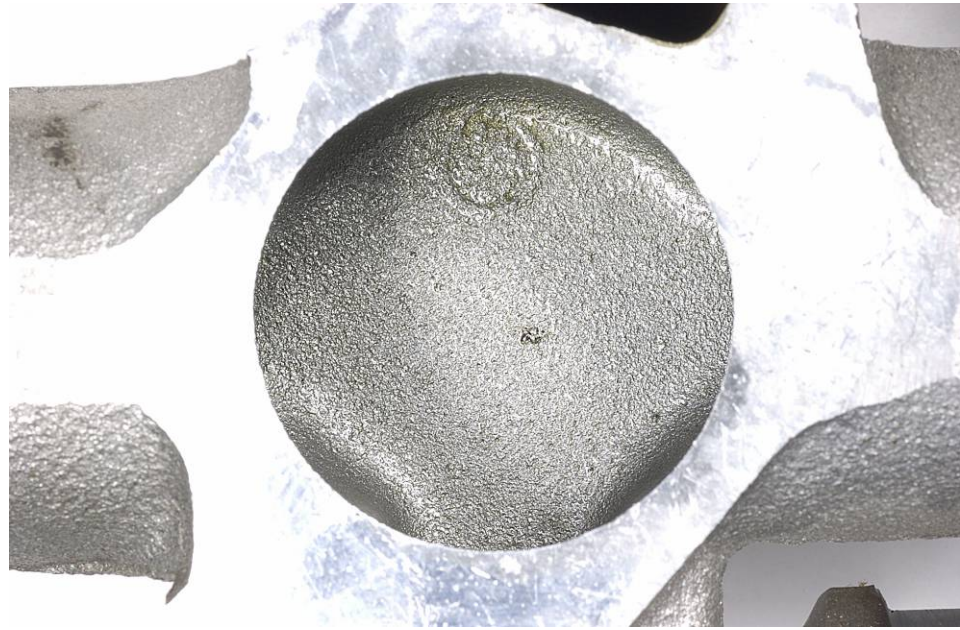


**Mixer bowl
deposits without
Additive**

Impact of Additive on Deposits



**Intake manifold
deposits with
Additive**



**Intake manifold
deposits without
Additive**

Impact of Additive on Deposits

PROPANE
EXCEPTIONAL ENERGY[®]



**Intake valve
deposits with
Additive**



**Intake valve
deposits without
Additive**

Study of Deposit Formation and Control (PERC docket 12116)

Studying the effects of various factors on deposit formation and control

- Vaporizer discharge temperature
- Heavy end composition and concentration
- Filters
- Additives

Test Plan

Additive tests (on engine)

- 1) Baseline (no additive)
- 2) Suburban LFC-774
- 3) CGX-4
- 4) Bell Pro 2000

Temperature tests (on rig)

- 5) 140°F fuel temperature at vaporizer outlet*
- 6) 80°F fuel temperature at vaporizer outlet

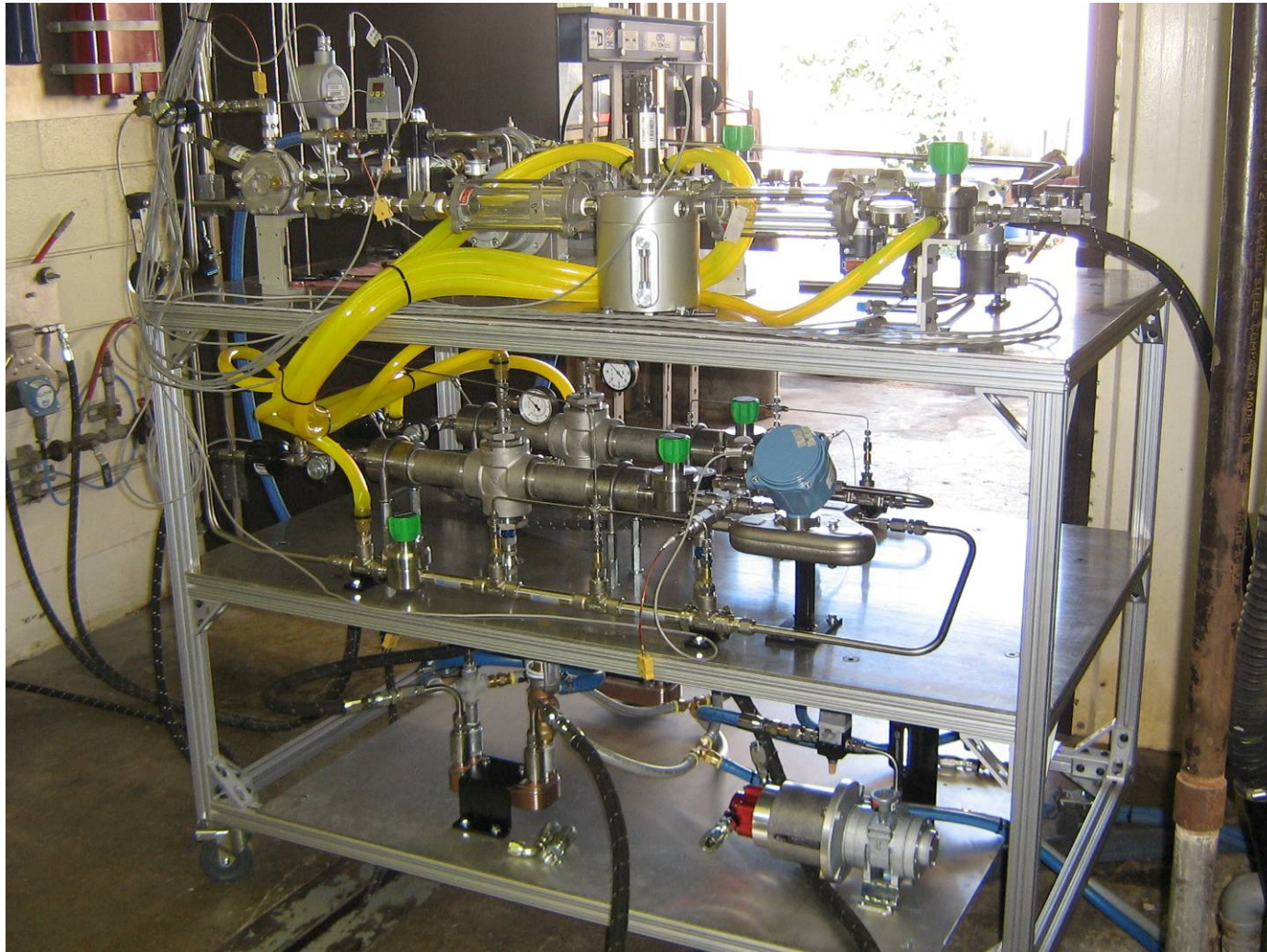
Filter tests (on rig)

- 7) Liquid-side filter
- 8) Vapor-side filter

* 140°F temperature test will serve as no-filter baseline

LPG Deposit Test Rig

PROPANE
EXCEPTIONAL ENERGY[®]



Test Rig Controls and Instrumentation

- Fuel supply temperature
- Fuel supply pressure
- Fuel discharge temperature
- Fuel discharge pressure
- Fuel flow rate
- Coolant flow rate
- Coolant temperature
- Heavy end composition
- Heavy end concentration

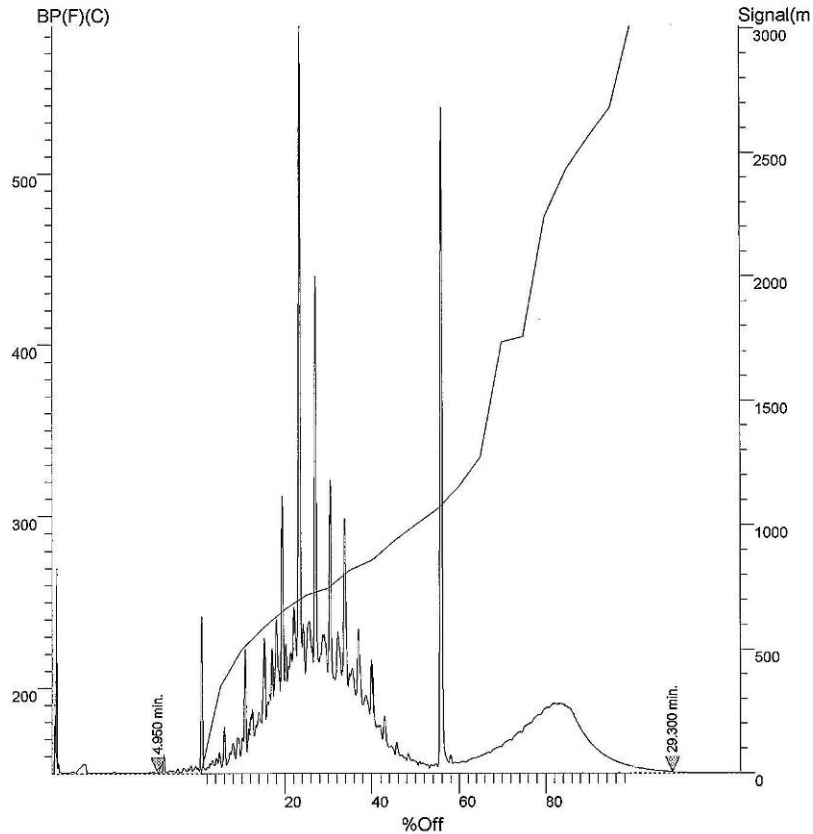
Rig Deposit Visualization



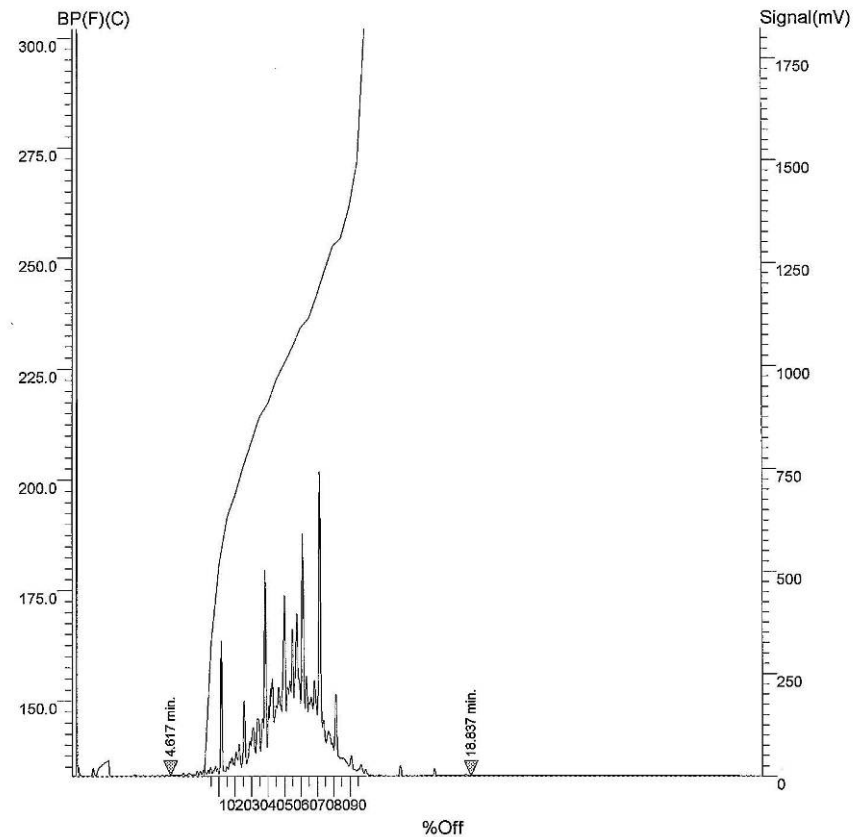
Test Rig Sample Collection Points

- Liquid LPG sample - analyze heavy end residue in supplied fuel
- Deposit sample - analyze deposits
- Vapor LPG sample - analyze residue remaining in fuel after vaporizer

Test 1 Simulated Distillation ASTM D2887

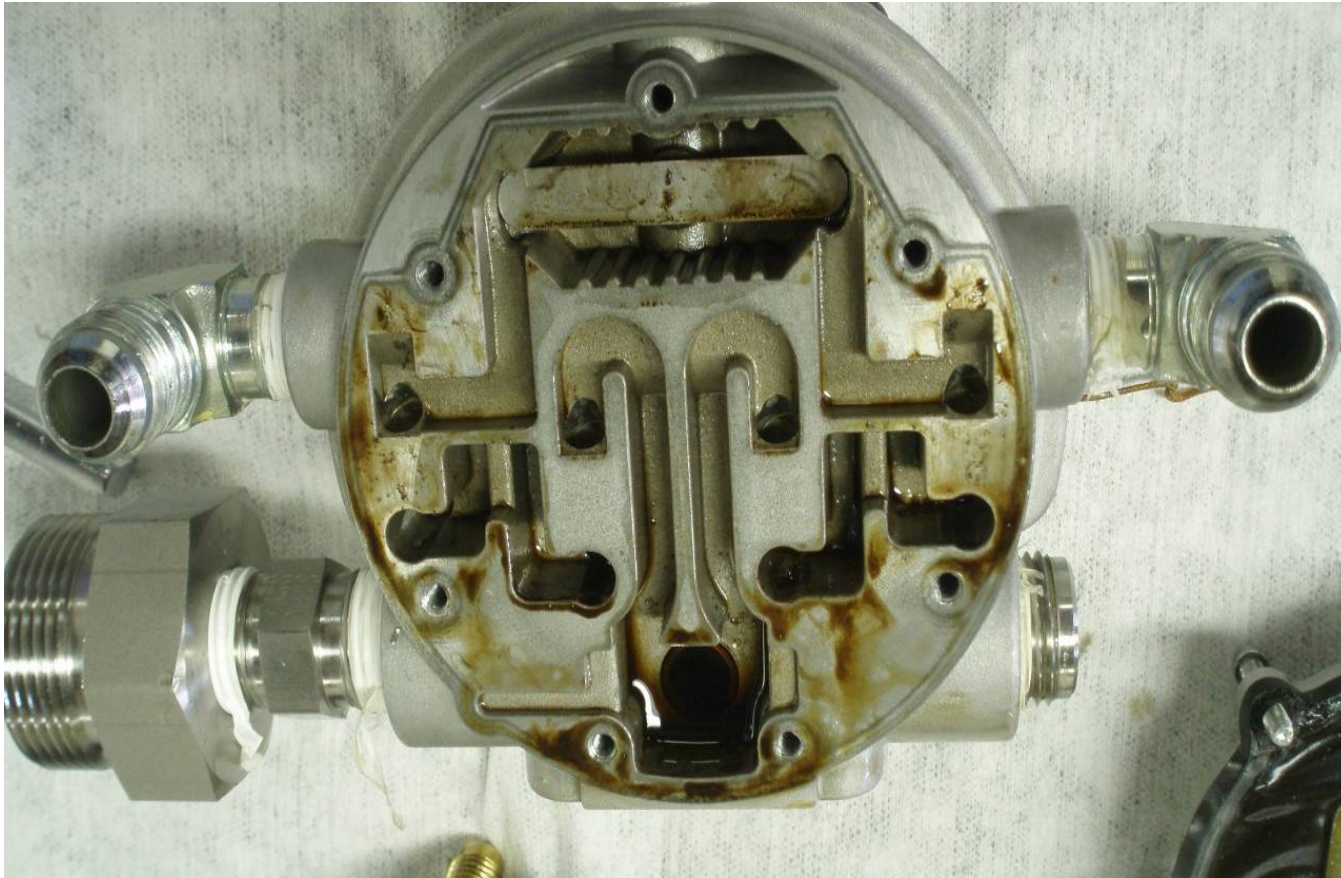


Residue LPG Liquid



Residue LPG Vapor

Post Test Vaporizer Inspection



For Additional Information

Visit the PERC web sites:

www.propanecouncil.org

www.propaneresearch.com