The Effect of Oxygenates on Fuel Economy

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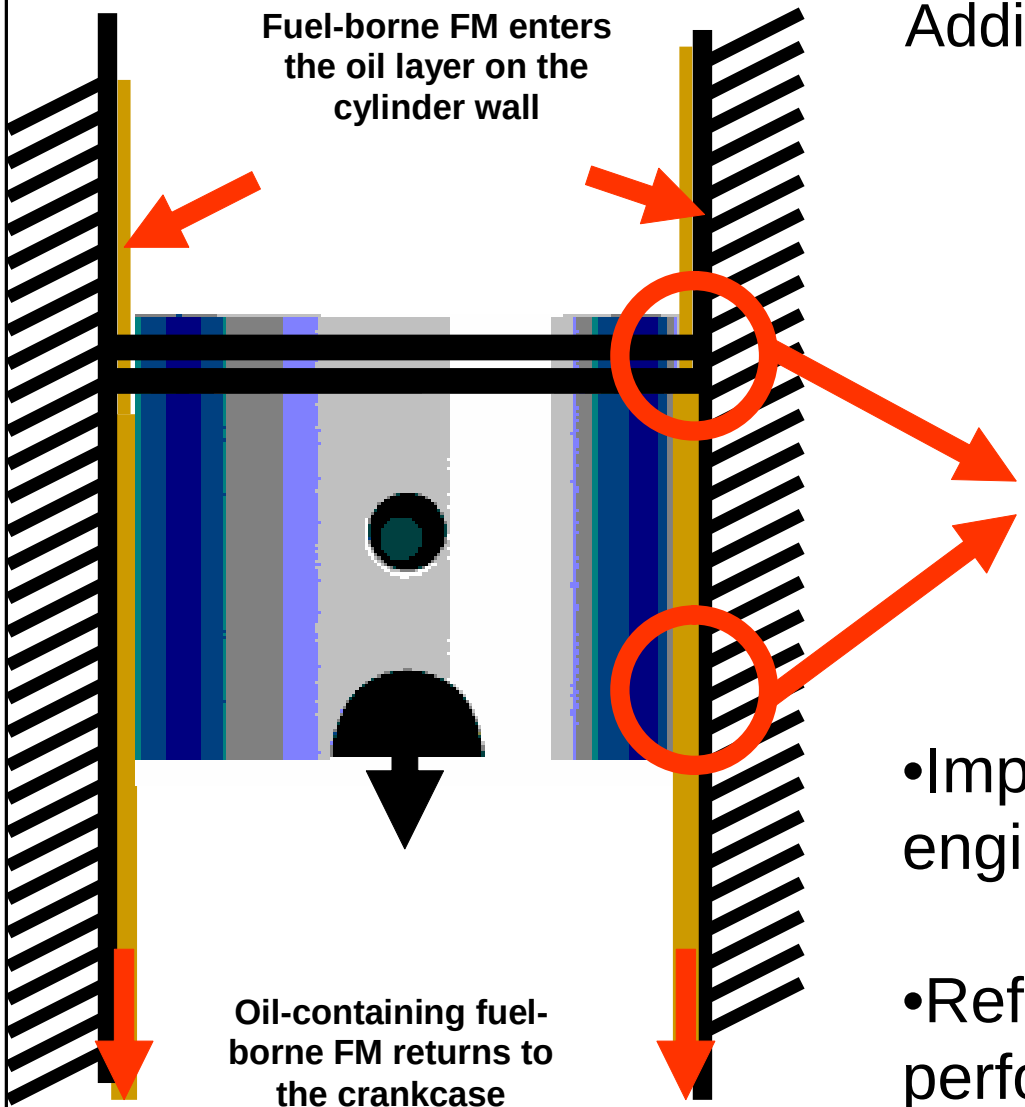
Fuel Economy Drivers

- Reduced Emissions
- Reduced Fuel Consumption
  - Limited Natural Resources
- Restrictions on Octane Boosters
  - TEL, MTBE, MMT
- EtOH Effects on “One Tank” Fuel Economy
  - Reduction of 2-5%
- Consumer Perspective – Fuel Cost
- Fuel Economy Additives can make a contribution
  - Improvement from 1 to 4%
- But there is there is no standard method for measuring fuel economy performance of fuel additives

Additive Function



Fuel-borne FM reduces friction in the areas where the piston rings and piston skirt are in close contact with the cylinder wall

- Improves internal friction of engine in the short term
- Refreshes friction performance of lubricant over time

The Effect of Oxygenates on Fuel Economy

Structure of talk

- Review of the development of fuels test based on M111E FE test (L54-T-96)
- Comparison of gasoline vs. gasohol in M111E FE test
- Comparison of gasoline vs. gasohol in Seq. VIB engine test

Measurement of FE Performance of Fuels

- There are some starting points for tests measuring fuel additive fuel economy performance

- Some tests already exist for measuring Fuel Economy for Engines and Lubricants
  - Lubricant tests
  - Drive cycles
  - MVEG draft protocol
  - Some bench tests exist for measuring lubricity of fuels

Measurement of FE Performance of Fuels

- This work concentrates only on the short-term effect

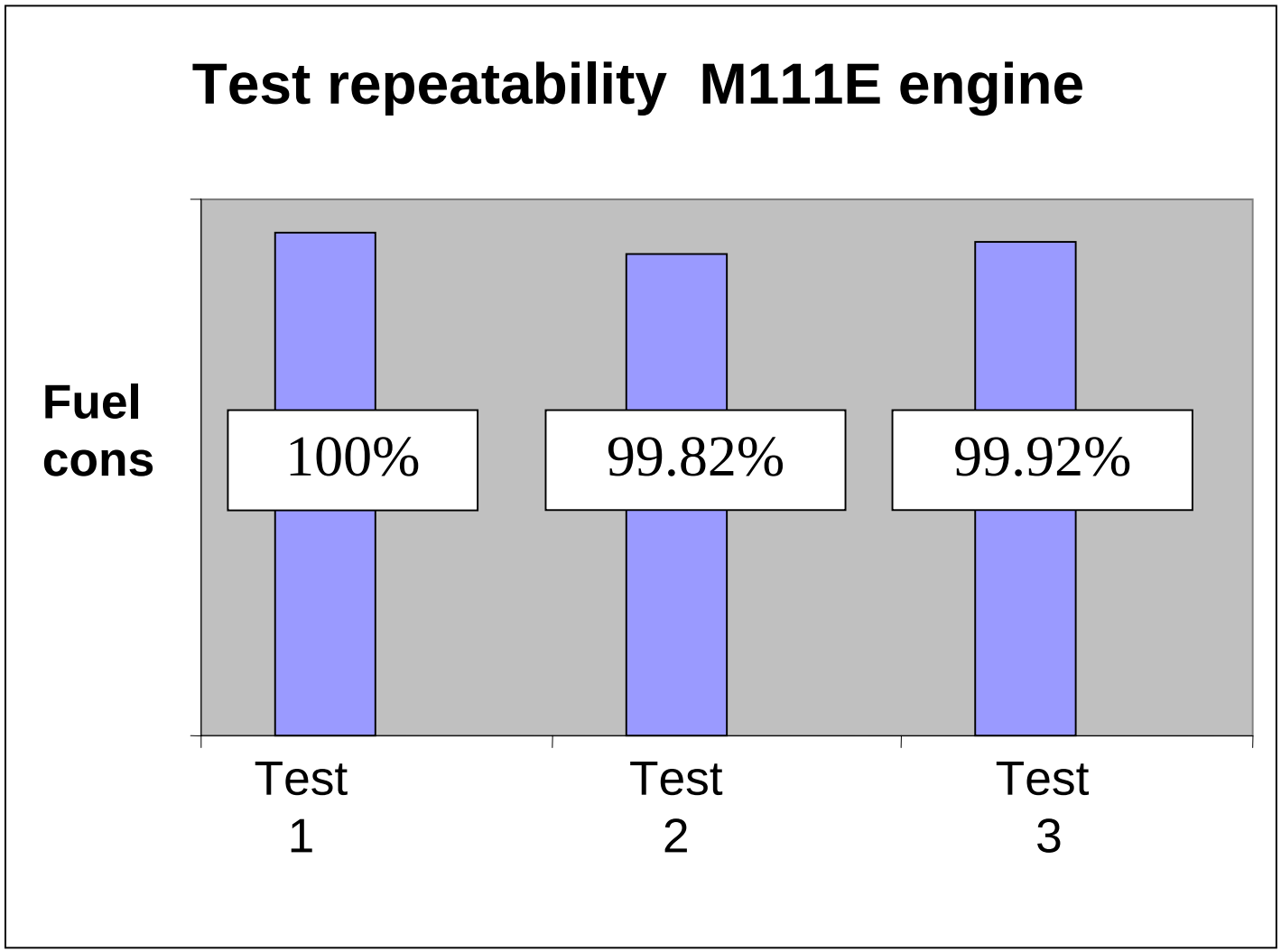
- Use best practice for experiments
  - Back-to-back reference data
  - Repeats
  - Check for drift
  - Neutralise oil aging effects
  - Neutralise carry-over effects
  - Eliminate/neutralise the many other variables

Development of Fuels Test
-Based on M111 FE Lubricant Test (L54-T-96)

Based on well established, reliable test

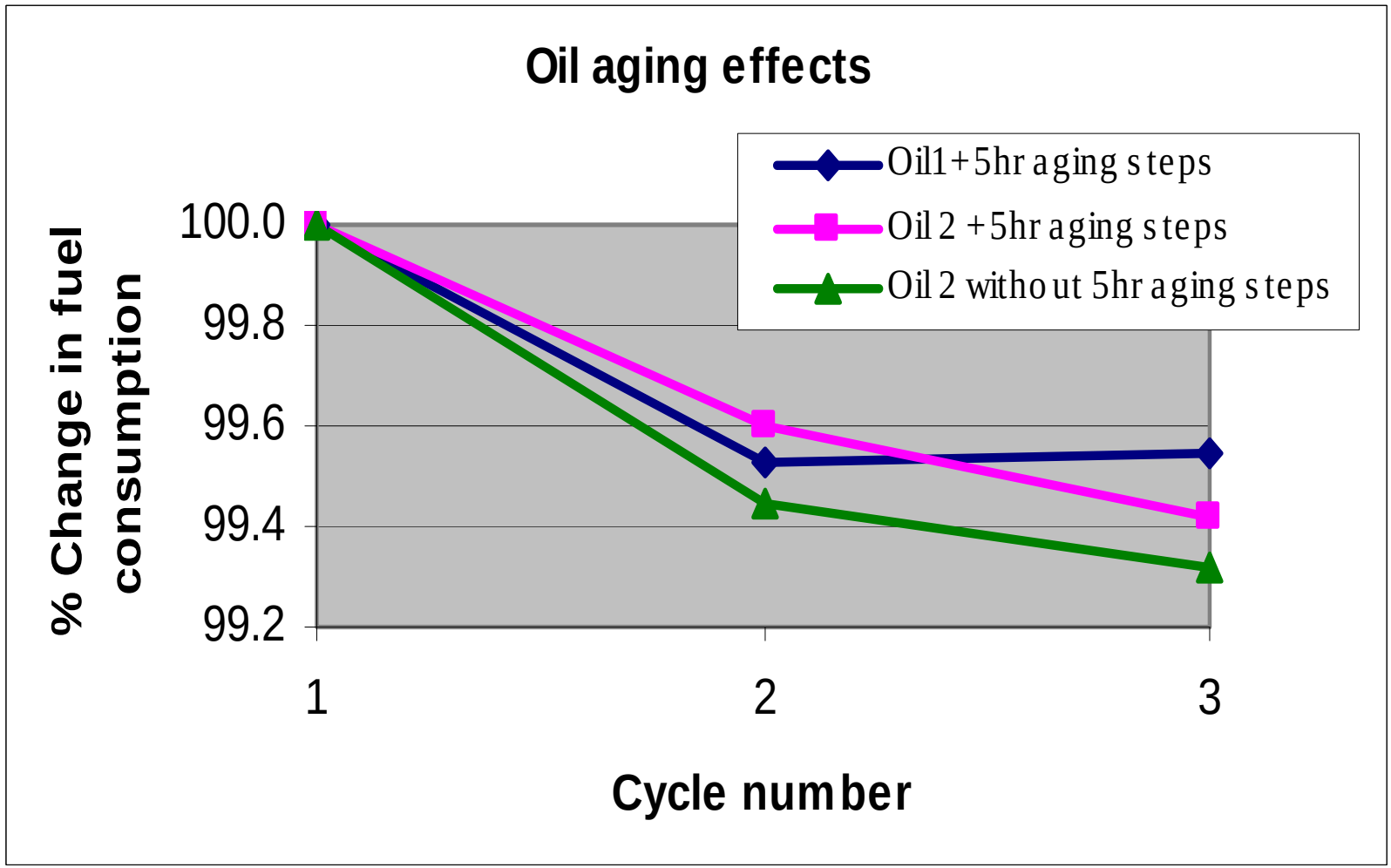
- Equipment widely available
- Ability to change/flush oils while engine runs
- Relevant to Europe
  - Engine
  - Drive cycle (ECE/EUDC)
- Test Fuels
  - Reference fuel = RF89
  - Candidate Fuels = RF89 dosed with additive

Development of Fuels Test

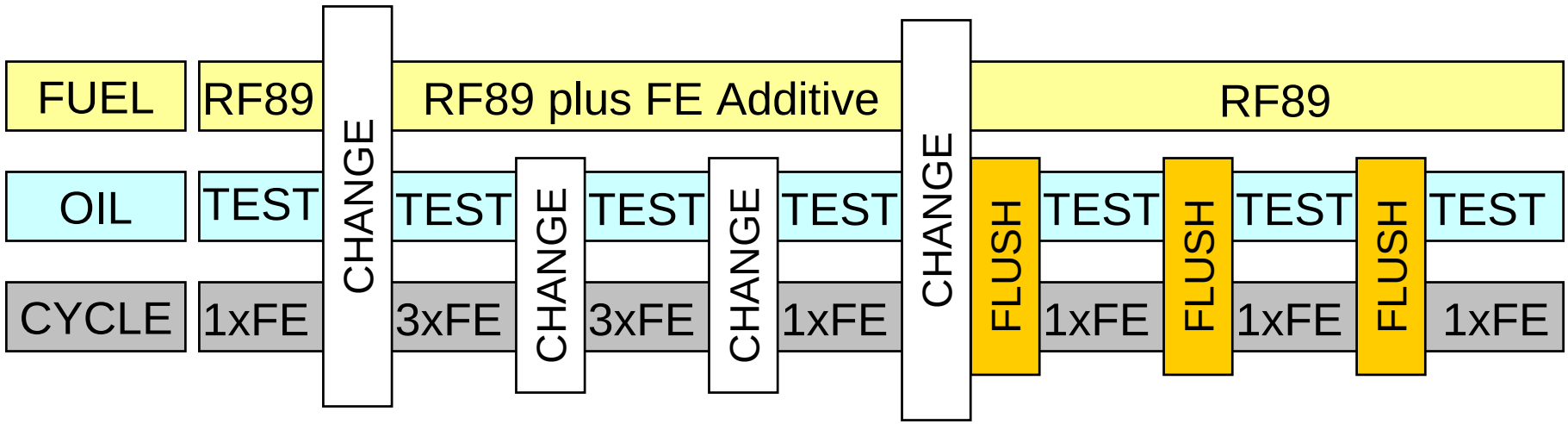


Development of Fuels Test

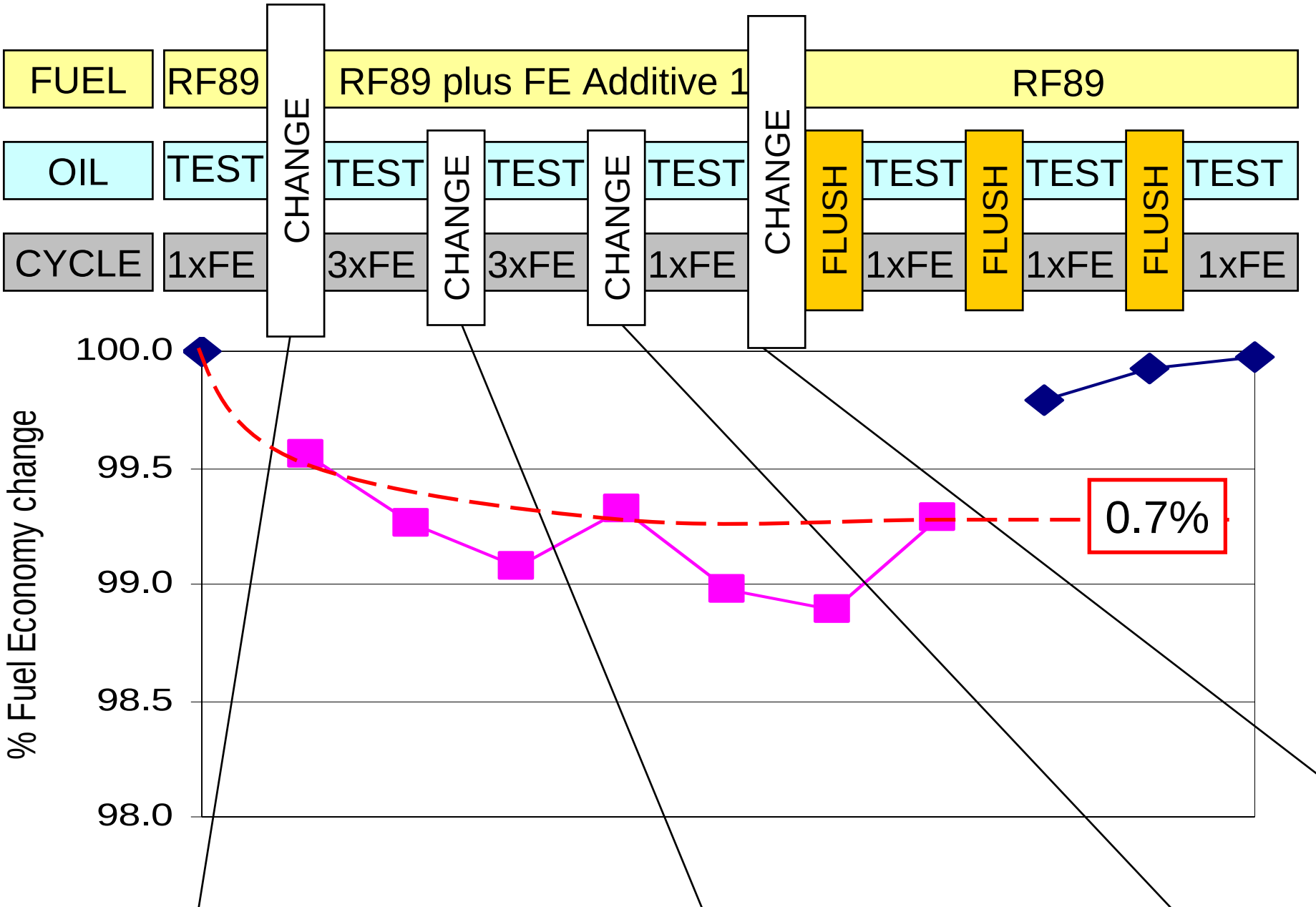
- Test oils
  - Oil 1
    - RL191 (15W-40 with no friction modifier)
  - Oil 2
    - 5W-30 A3-02, B3-98, SL, CF
    - Contains ashless friction modifier
    - Offers improved fuel economy performance
  - Flushing oil
    - RL190

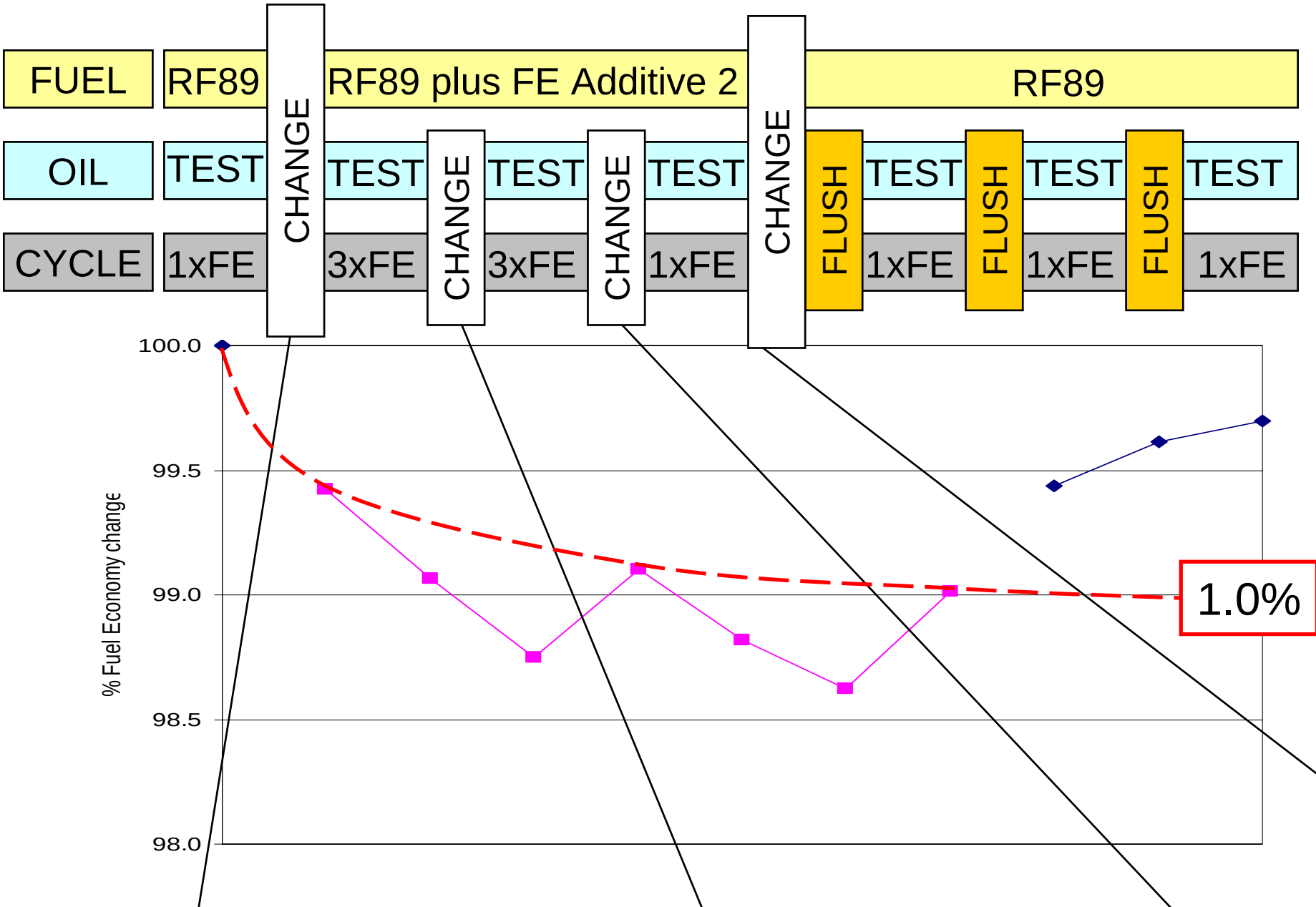

Oil aging effects
Oil1+5hr aging steps
Oil 2 +5hr aging steps
Oil 2 without 5hr aging steps
% Change in fuel consumption
100.0
99.8
99.6
99.4
99.2
1
2
3
Cycle number

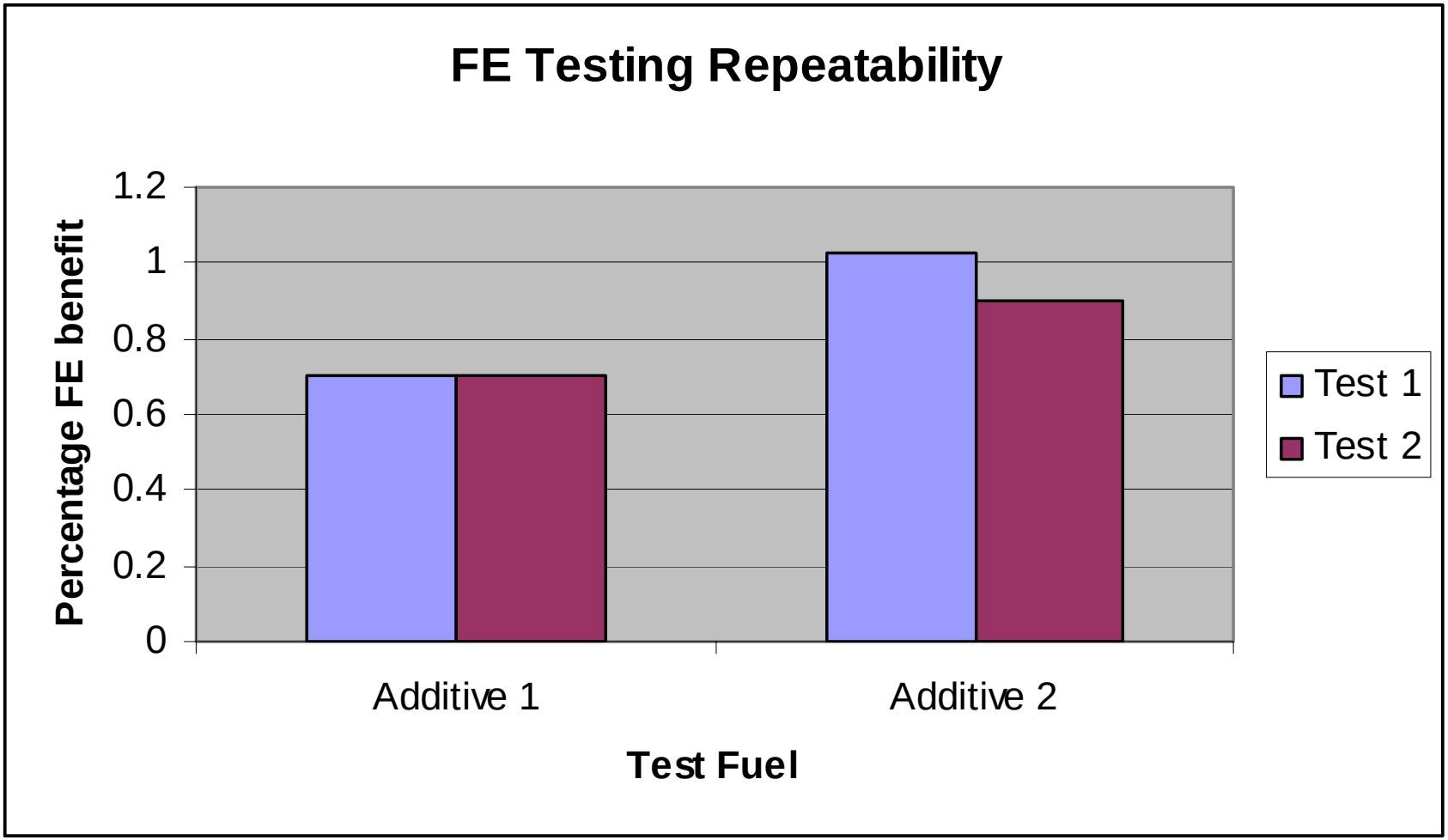
Development of Fuels Test
-Procedure



TEST OIL = Oil 2 (5W-30)
FLUSH OIL = RL190, 1hour flushing cycle
FE = L54-T-96 Fuel economy cycle (2hrs 45 min ECE/EUDC)

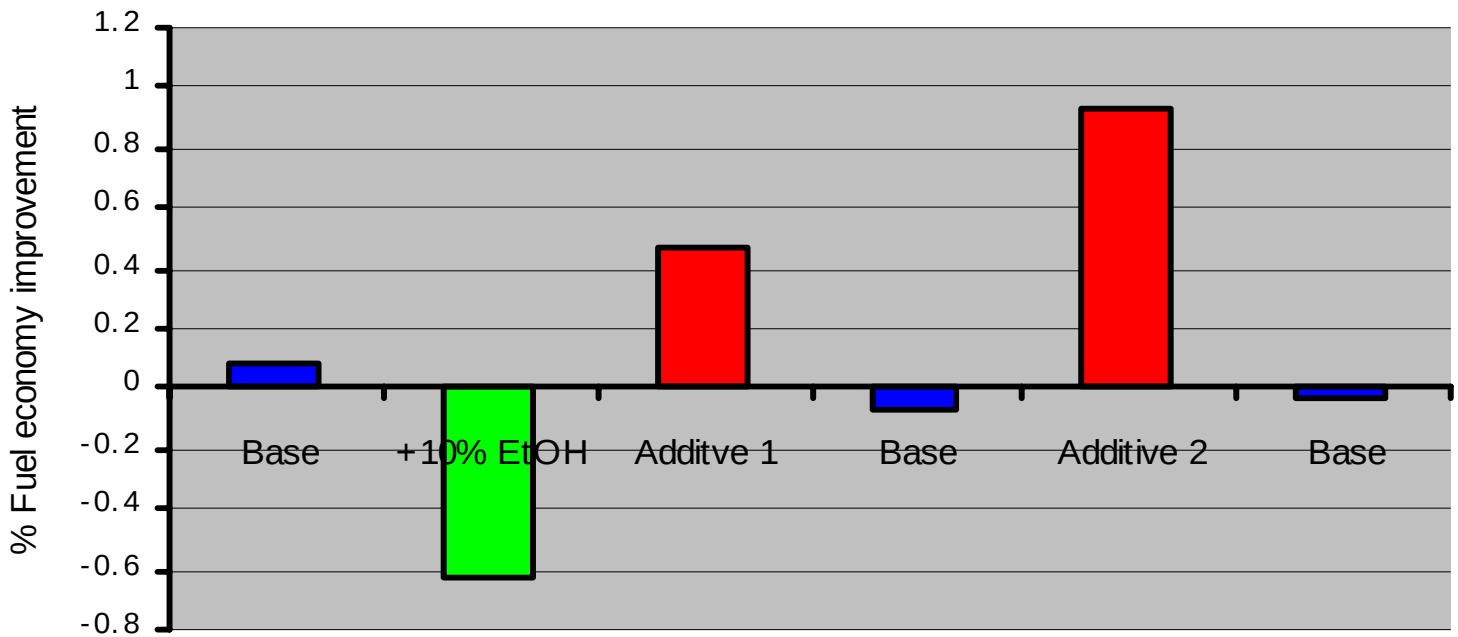

FUEL
RF89
RF89 plus FE Additive 1
RF89
OIL
TEST
TEST
TEST
TEST
TEST
TEST
TEST
CYCLE
1xFE
3xFE
3xFE
1xFE
1xFE
1xFE
1xFE
CHANGE
CHANGE
CHANGE
CHANGE
FLUSH
FLUSH
FLUSH
100.0
99.5
99.0
98.5
98.0
% Fuel Economy change
0.7%


FUEL
RF89
RF89 plus FE Additive 2
RF89
OIL
TEST
TEST
TEST
TEST
TEST
TEST
TEST
CYCLE
1xFE
3xFE
3xFE
1xFE
1xFE
1xFE
1xFE
CHANGE
CHANGE
CHANGE
CHANGE
FLUSH
FLUSH
FLUSH
100.0
99.5
99.0
98.5
98.0
% Fuel Economy change
1.0%


FE Testing Repeatability
Percentage FE benefit
1.2
1
0.8
0.6
0.4
0.2
0
Additive 1
Additive 2
Test Fuel
Test 1
Test 2

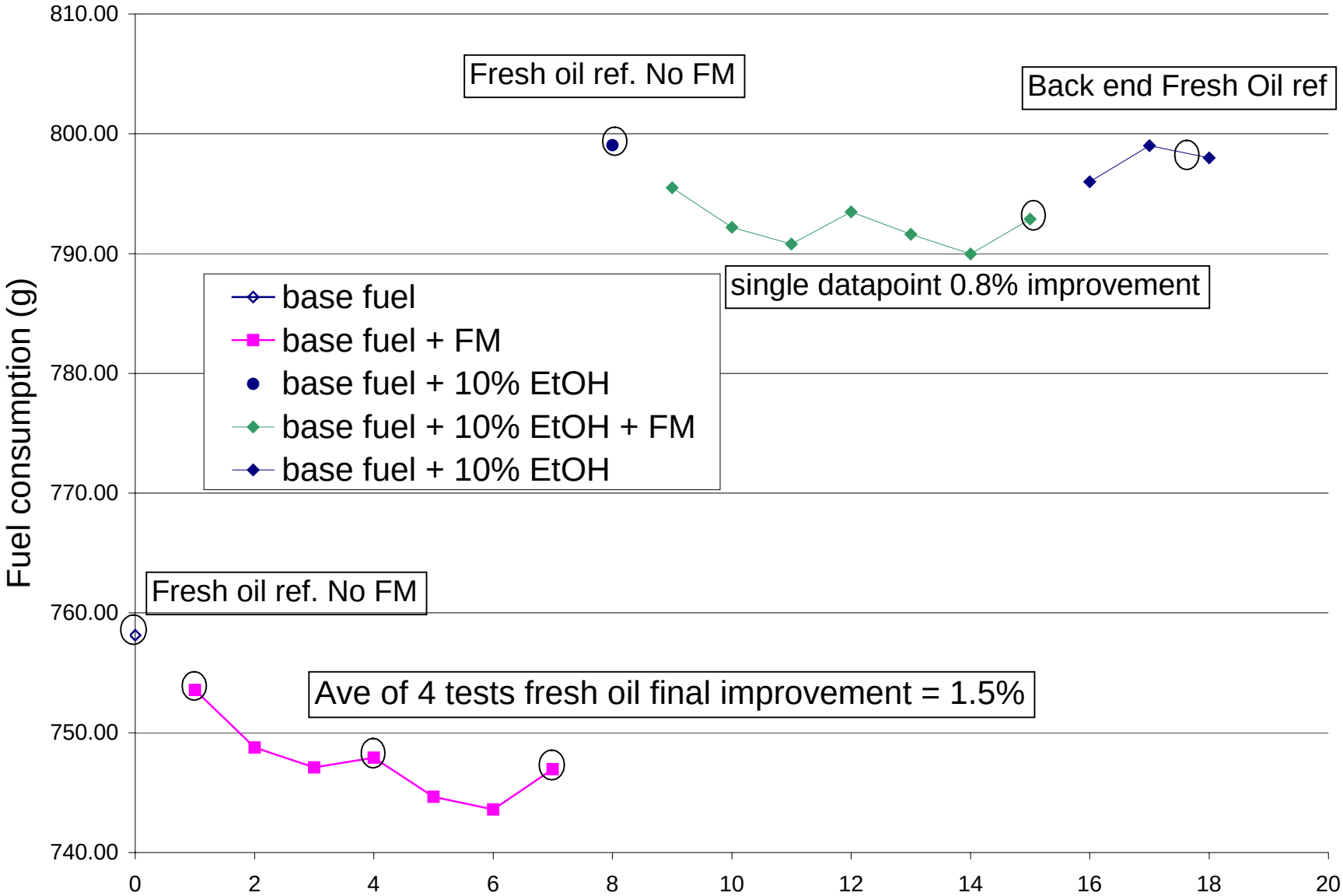
Comparison with some previous engine test data

Sequence VI Engine Testing of Fuel additives



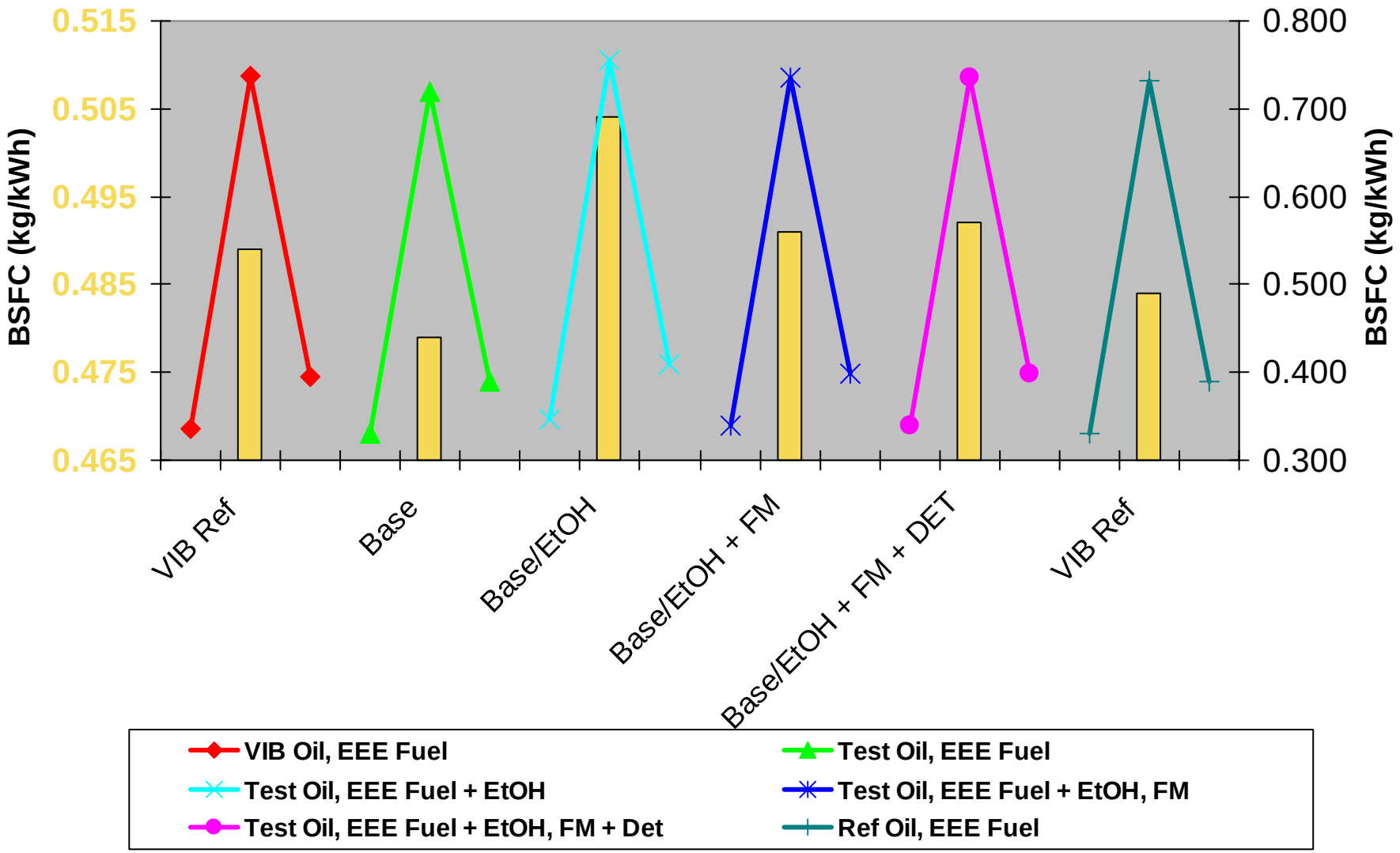
Gasoline vs. gasohol evaluation in M111E

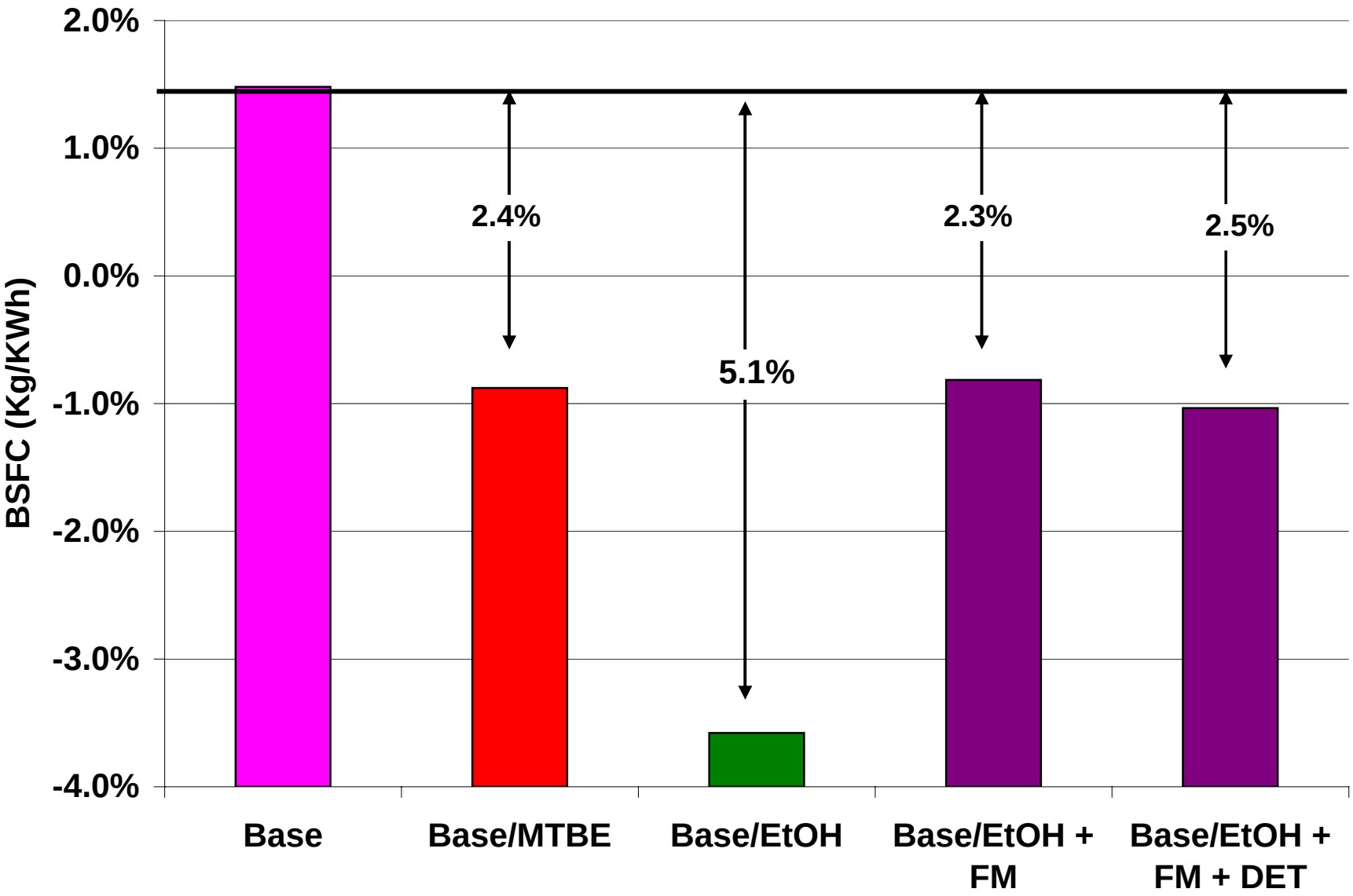
- Test Conditions and Variables
  - Test Fuels
    - RF89
    - RF89 + FE Additive 1
    - RF89 + 10% EtOH
    - RF89 + 10% EtOH + FE Additive 1
  - Test Oil
    - 5W-30 A3-02, B3-98, SL, CF
    - Contains ashless friction modifier
    - Offers improved fuel economy performance
  - Flushing oil
    - RL190


Fuel consumption (g)
810.00
800.00
790.00
780.00
770.00
760.00
750.00
740.00
0
2
4
6
8
10
12
14
16
18
20
Fresh oil ref. No FM
Back end Fresh Oil ref
single datapoint 0.8% improvement
base fuel
base fuel + FM
base fuel + 10% EtOH
base fuel + 10% EtOH + FM
base fuel + 10% EtOH
Fresh oil ref. No FM
Ave of 4 tests fresh oil final improvement = 1.5%

Gasoline vs. gasohol evaluation in Sequence VIB

- Test Conditions and Variables
  - Test Fuels
    - Emissions Fuel
    - Emissions Fuel + EtOH (or other octane booster)
    - Emissions Fuel + EtOH + FE Additive 1
    - Emissions Fuel + EtOH + FE Additive 1 + Detergent
  - Test Oil
    - VIB Reference Oil
    - 5W-30 Proprietary Blend
      - Contains ashless friction modifier
      - Offers improved fuel economy performance


0.515
0.505
0.495
0.485
0.475
0.465
BSFC (kg/kWh)
0.800
0.700
0.600
0.500
0.400
0.300
BSFC (kg/kWh)
VIB Ref
Base
Base/EtOH
Base/EtOH + FM
Base/EtOH + FM + DET
VIB Ref
VIB Oil, EEE Fuel
Test Oil, EEE Fuel
Test Oil, EEE Fuel + EtOH
Test Oil, EEE Fuel + EtOH, FM
Test Oil, EEE Fuel + EtOH, FM + Det
Ref Oil, EEE Fuel


2.0%
1.0%
0.0%
-1.0%
-2.0%
-3.0%
-4.0%
BSFC (Kg/KWh)
2.4%
5.1%
2.3%
2.5%
Base
Base/MTBE
Base/EtOH
Base/EtOH + FM
Base/EtOH + FM + DET

Conclusions

- No protocol exists for measuring the effect of fuel-borne additives on fuel economy performance
- The M111E and Sequence VIB engine tests provide accurate and repeatable procedure for screening additives and validating performance
- These results are supplemented with more extensive data in several engine technologies
- Both M111E and Seq. VIB engine tests show the ethanol induced fuel economy reduction.
- FE additive improves fuel economy in gasoline and gasohol