

Technical Information

METI's Conformity Test for Ethanol Blend Gasoline

**Energy Efficiency and Conservation Authority
Bio Fuels Conference 2006**

April 21, 2006

**Fuels and Lubricants Committee
Japan Automobile Manufacturers Association**

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1. Characteristic of ethanol
2. Effects of ethanol blending on vehicle performances
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 - 2.2 Evaporative emissions
 - 2.3 Driveability
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3. Counter measures of vehicles for ethanol
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5. Position of Autos on Ethanol
6. JAMA's recommendation

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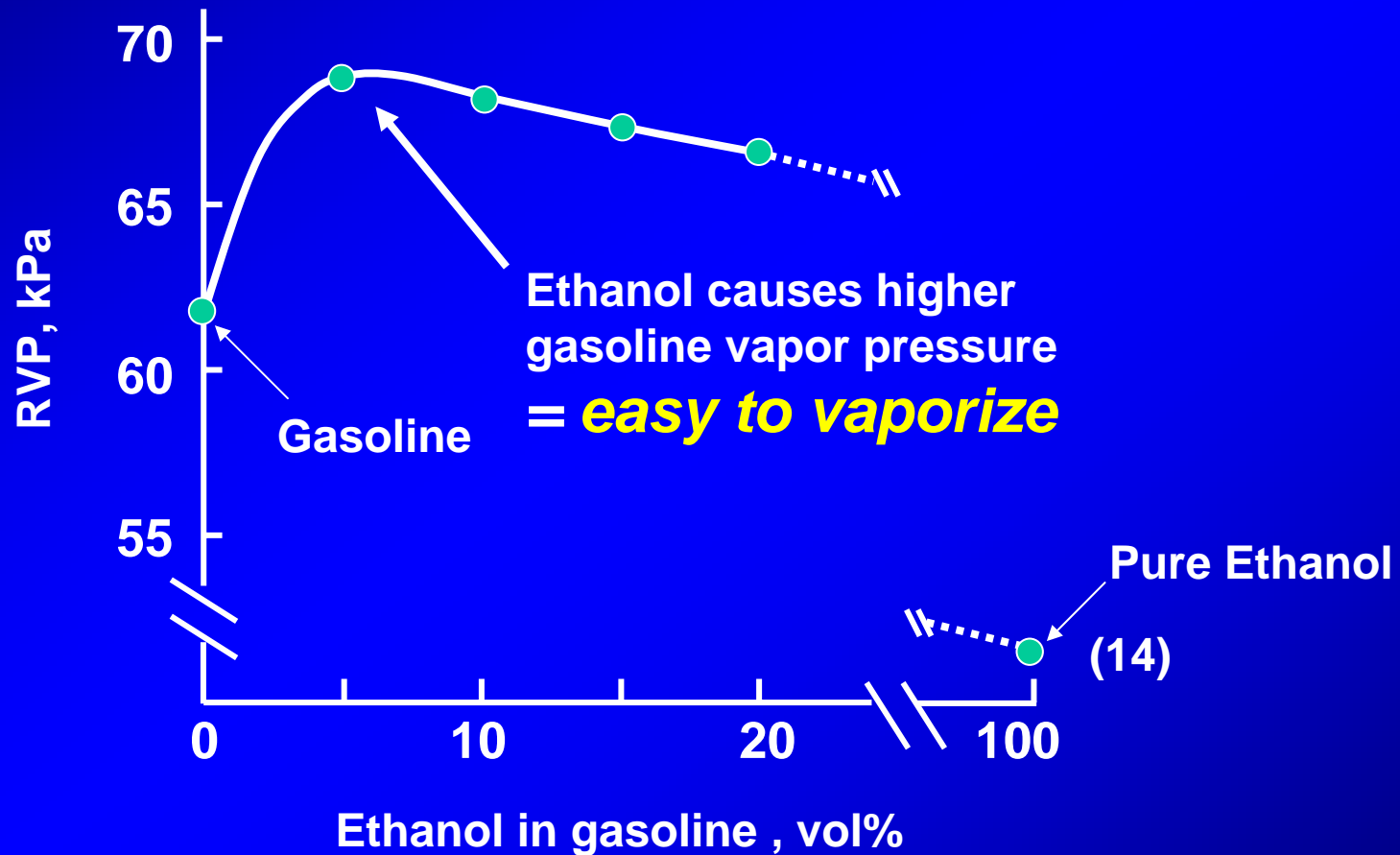
Characteristics of Ethanol

| | Gasoline | MTBE | ETBE | Ethanol |
|---------------------|------------|--------------------------------|---|---------------------------------|
| Composition | C4 - C12 | $(\text{CH}_3)_3\text{COCH}_3$ | $(\text{CH}_3)_3\text{COC}_2\text{H}_5$ | $\text{C}_2\text{H}_5\text{OH}$ |
| Molecular Weight | 100-105 | 88 | 102 | 46 |
| Oxygen Content wt% | 0 | 18.2 | 15.7 | 34.7 |
| Density | 0.72-0.78 | 0.746 | 0.745 | 0.794 |
| Boiling point deg.C | 30-220 | 55 | 72 | 78 |
| RVP , kPa | 44-78 | 54 | 28 | 14 |
| Water solubility % | Negligible | 4.8 | 1.2 | 100 |
| Latent heat BTU/gal | 900 | 863 | 863 | 3340 |

- High oxygen content and solubility of water

Characteristics of Ethanol

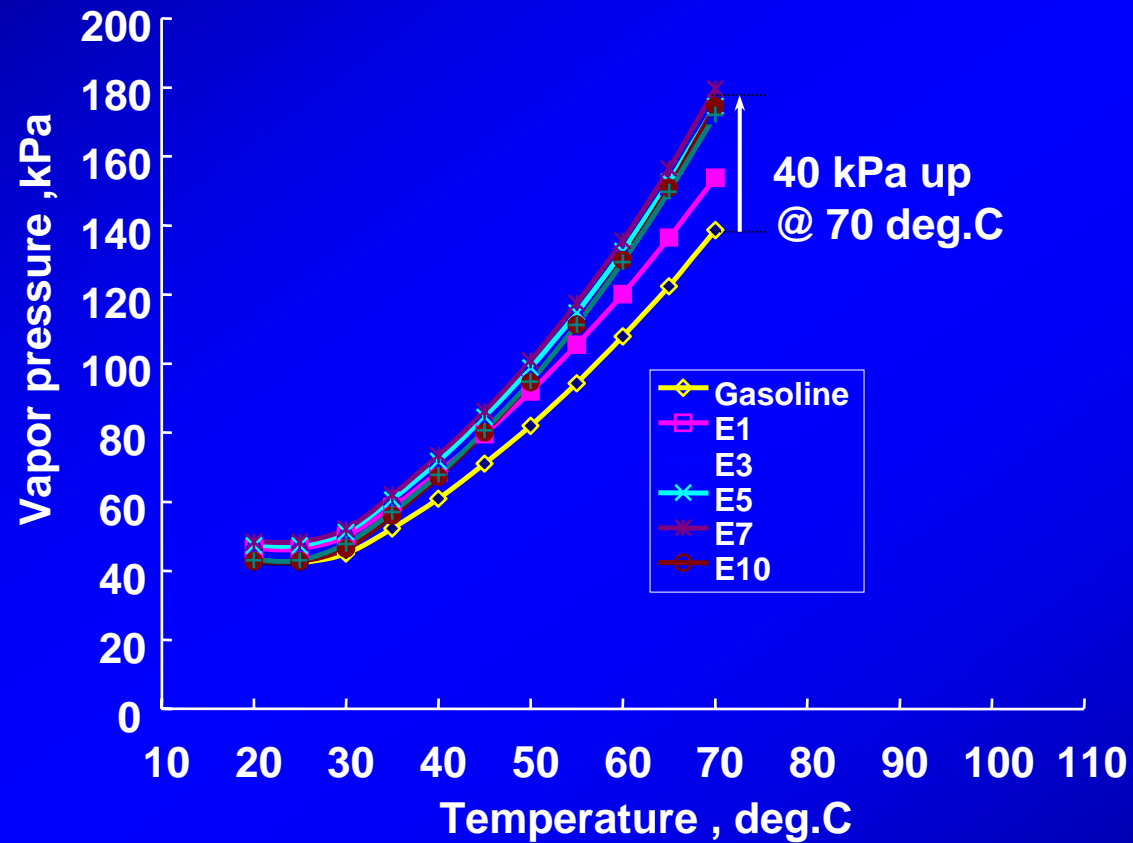
Azeotropic Phenomena - Effects on RVP



- Blend of ethanol increases RVP.

Characteristics of Ethanol

Temperature Effects on Vapor pressure



- More easy to produce vapor at higher temperature as blending ethanol

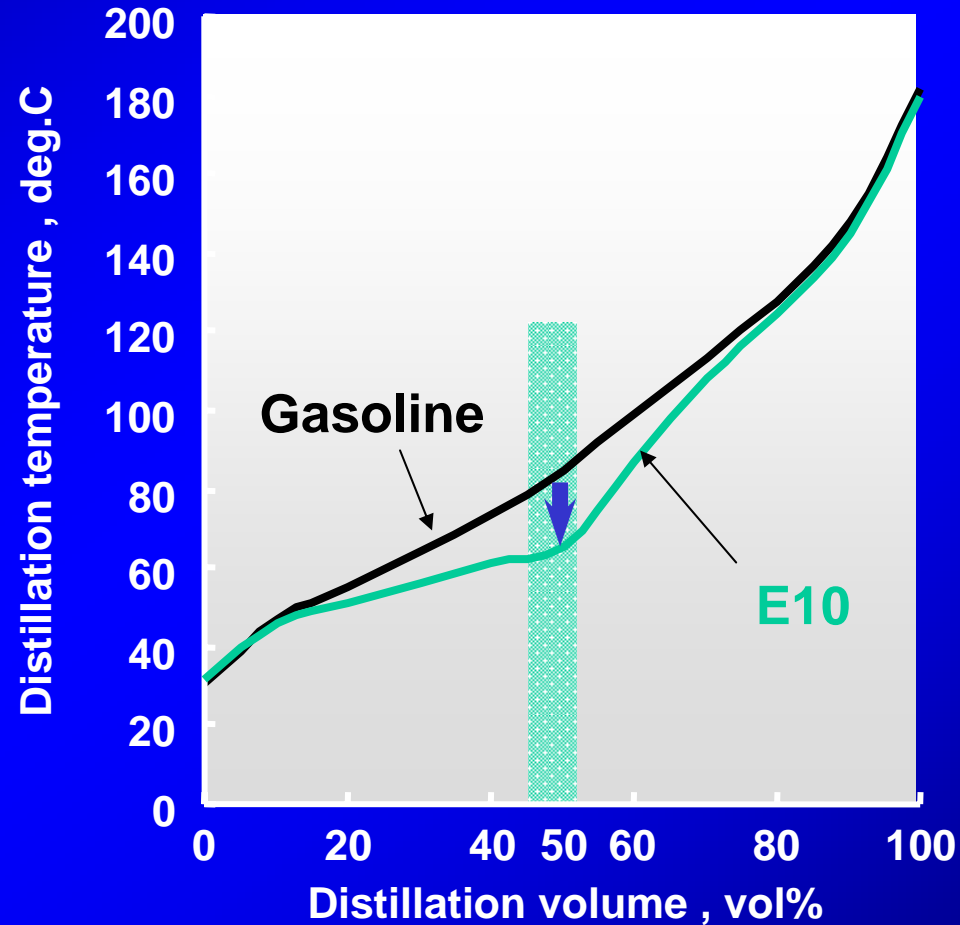
Characteristics of Ethanol

Azeotropic Phenomena - Effects on distillation properties

Large change
of 50% distillation
temperature



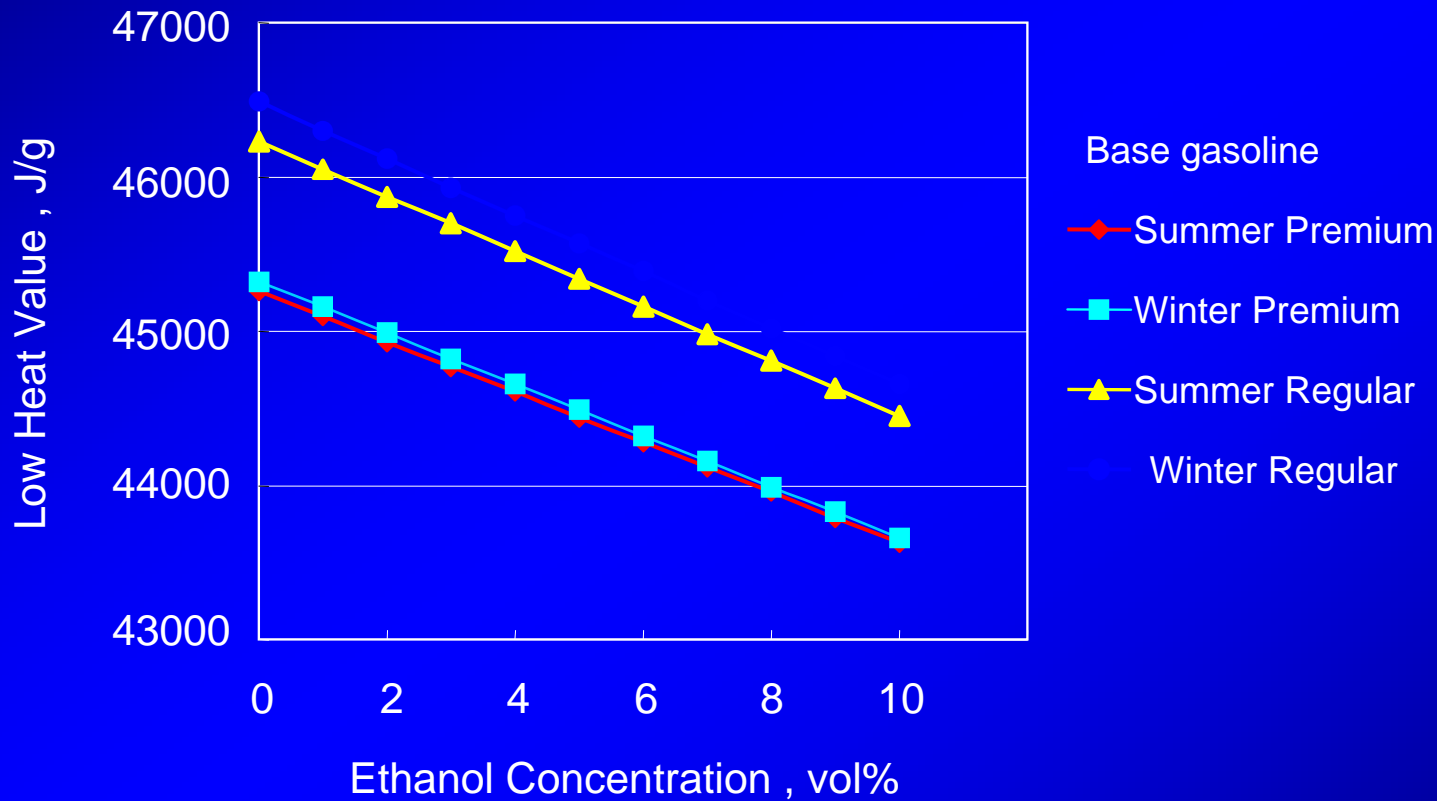
50% distillation
temperature
effects on
- driveability
- HC emission



- Blending ethanol lowers T50 significantly.
- This affects driveability and exhaust emissions .

Characteristics of Ethanol

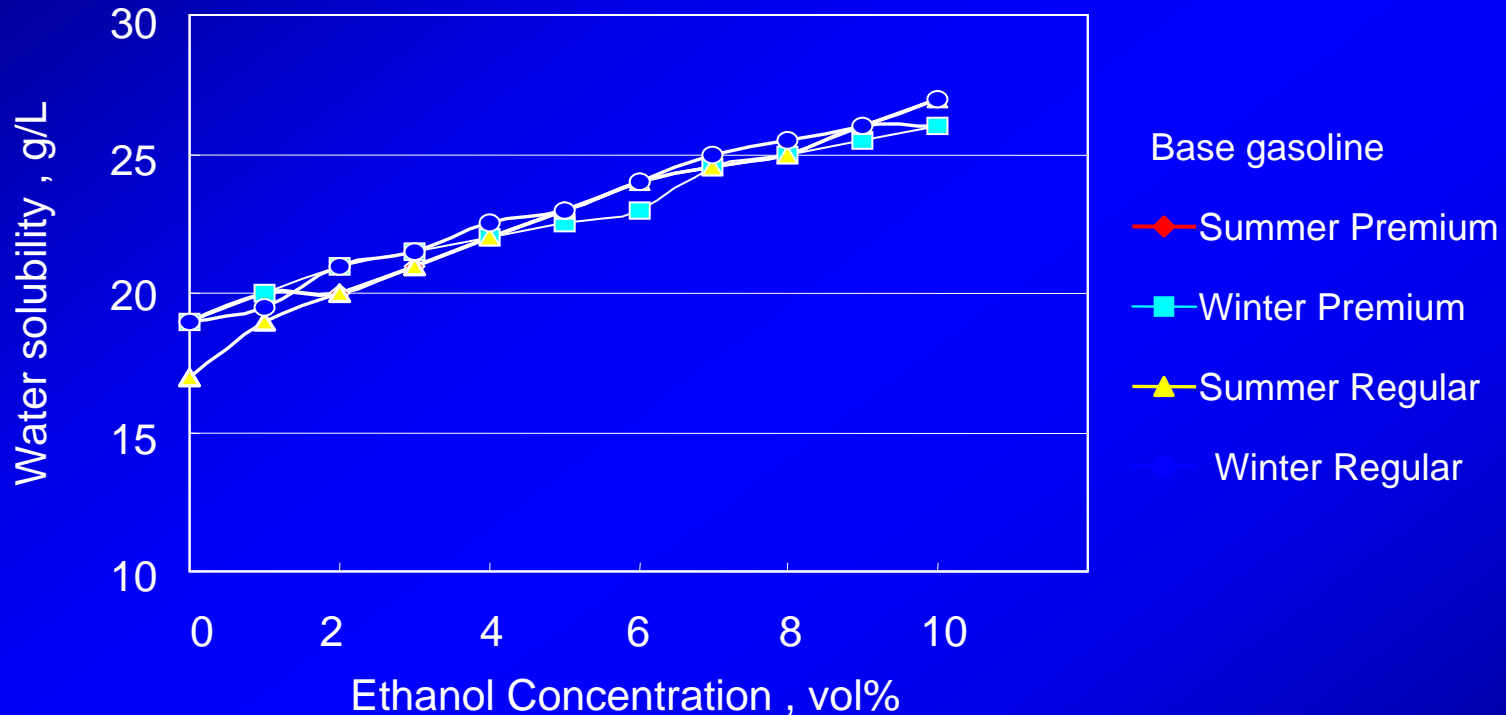
Effects on Heat Value



- Blending ethanol lowers heat value.
- In the case of E10, worsen of fuel economy is estimated by 3%.

Characteristics of Ethanol

Water solubility



Note ; 80mL of gasoline and 20mL of water was blended and then was shaken by 2 minutes.
After that, volume of water phase was measured.

- Ethanol blending gasoline dissolves water easily. In some cases, water dissolves in fuel line of vehicles. This water causes troubles such as corrosion.
- When ethanol blending gasoline is introduced, materials of facility in Service Station and good housekeeping in fuel delivery system are essential.

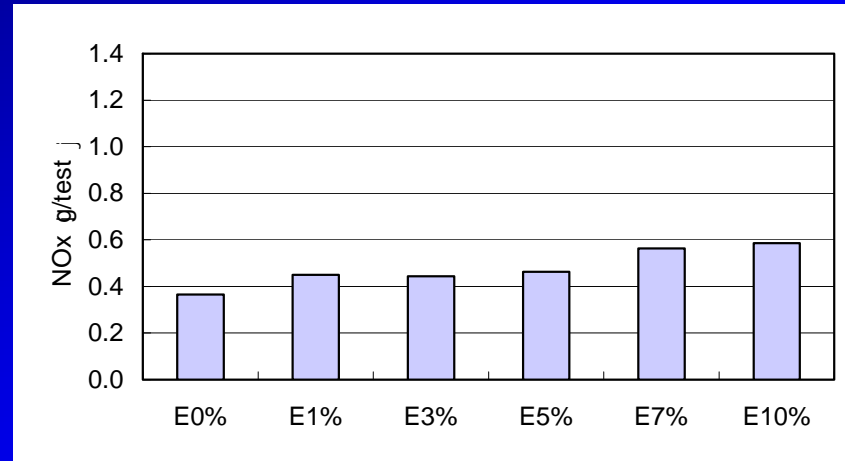
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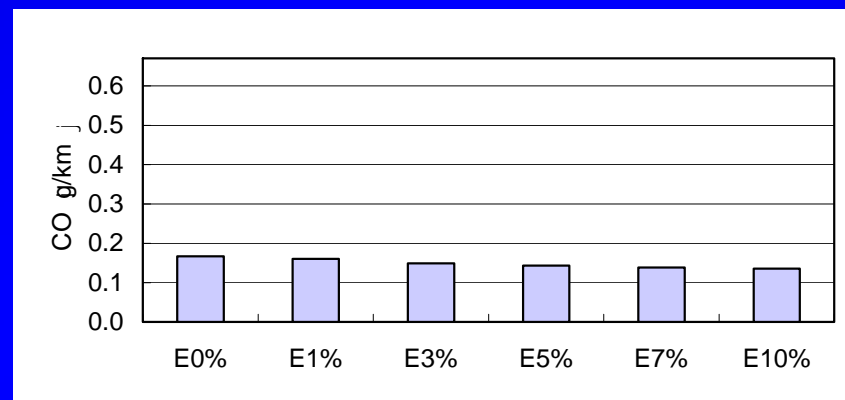
Example of Tailpipe Emissions



Japanese Regulation

NOx : 1.4 [g/test]

11mode, New Passenger Vehicle, SIDI, De-NOx



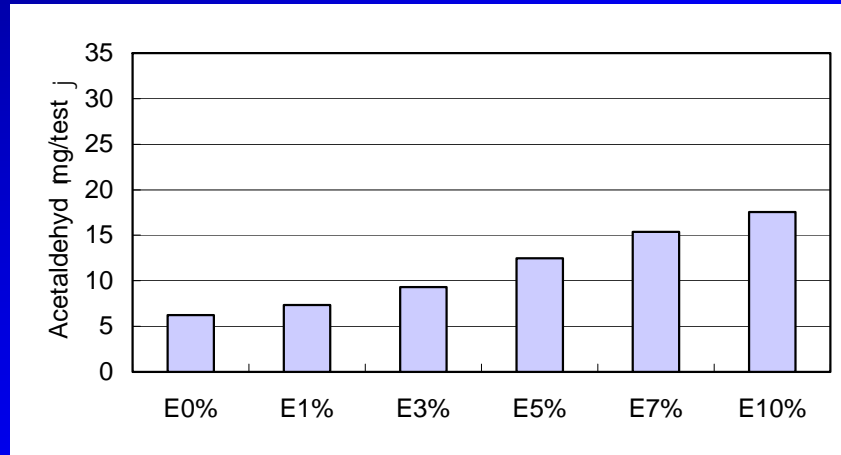
Japanese Regulation

CO : 0.67 [g/km]

10-15mode, New Light Vehicle, PFI, TWC

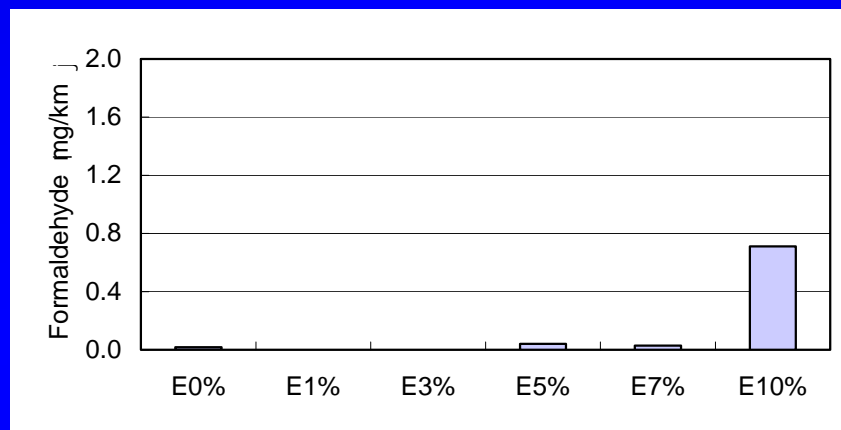
PFI : Port Fuel Injection
TWC : Three-way catalyst

Example of Tailpipe Emissions



11mode, 5years Light Vehicle, PFI, TWC

Japanese Regulation
Acetaldehyde : none



10-15mode, New Passenger Vehicle, PFI, TWC

Japanese Regulation
Formaldehyde : none

PFI : Port Fuel Injection
TWC : Three-way catalyst

Summary of Tailpipe Emissions

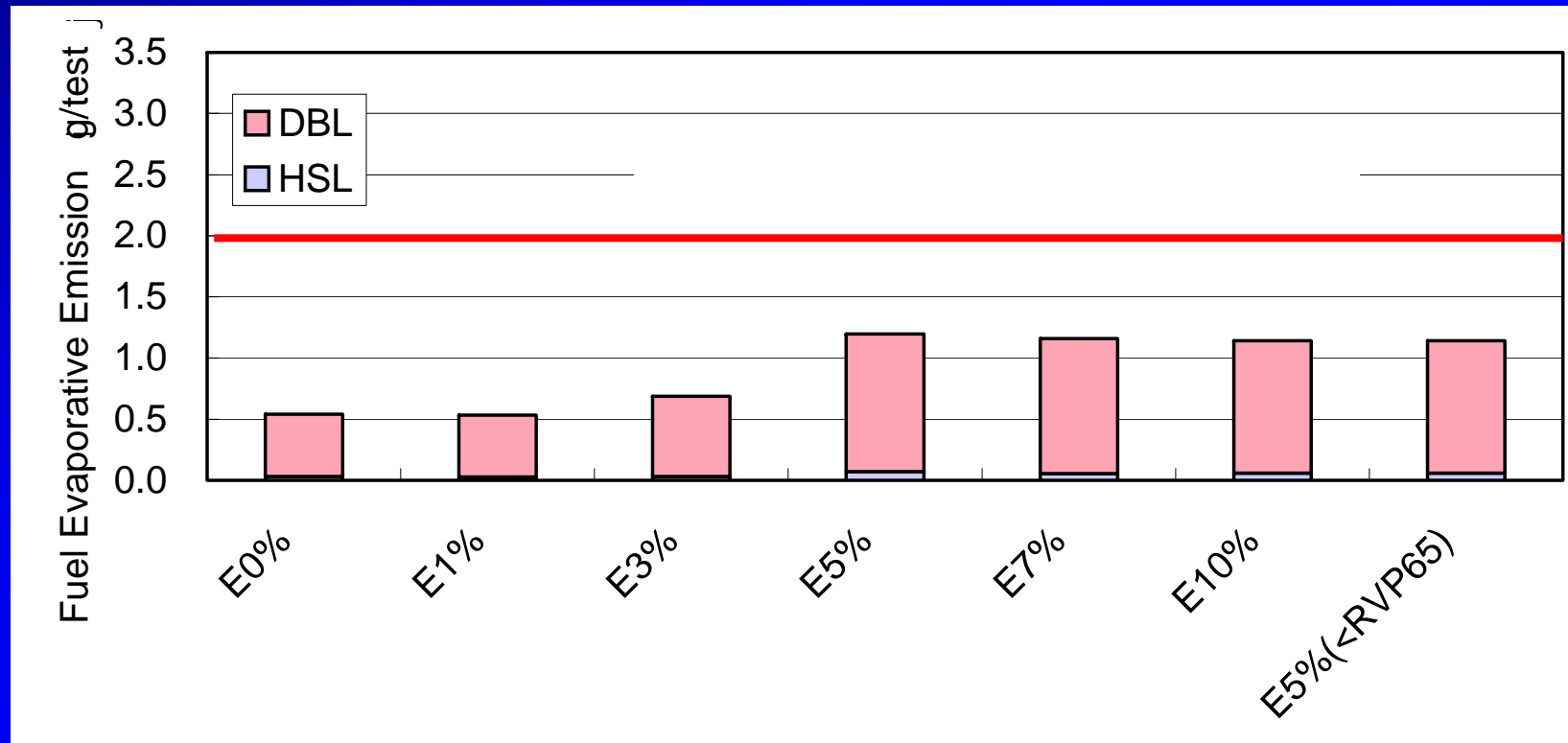
| ID | Type | Aged | Fuel supply | Displacement [cc] | After-treatment device | Knock sensor | Feedback | 10/15 mode | | | | | 11 mode | | | | | |
|----|--------------------|---------|-------------|-------------------|------------------------|--------------|----------|------------|-----|-----|------|---------------------|---------------------|-------------------------|-----|-----|------|---------------------|
| | | | | | | | | CO | THC | NOx | HCHO | CH ₃ CHO | CH ₂ CHO | CO | THC | NOx | HCHO | CH ₃ CHO |
| A1 | Passenger Vehicle | New | PFI | 1000 | TWC | W | W | ↘ | | | | ↗ | | | | | ↗ | ↗ |
| L | Passenger Vehicle | New | SIDI | 2400 | DeNOx | W | W | | | | | | | | ↗ | ↗ | | ↗ |
| B | Passenger Vehicle | 5years | PFI | 1800 | TWC | W | W | | | | | | | | | | | ↗ |
| C | Commercial Vehicle | 10years | CARB | 1500 | TWC | W/O | W/O | ↘ | | ↗ | ↗ | | | ↘ | | ↗ | | ↗ |
| D1 | Light Vehicle | New | PFI | 660 | TWC | W | W | ↘ | | | | | | | | | | ↗ |
| E | Light Vehicle | 5years | PFI | 660 | TWC | W/O | W | ↘ | | | ↗ | ↗ | | ↘ | | ↗ | | ↗ |
| G | Motorcycle | New | PFI | 250 | W/O | W/O | W/O | ↘ | ↘ | ↗ | | ↗ | | } TRIAS Motorcycle Mode | | | | |
| H | Motorcycle | 5years | CARB | 400 | W/O | W/O | W/O | ↘ | ↘ | ↗ | | ↗ | | | | | | |
| I | Motorcycle | 10years | CARB | 750 | W/O | W/O | W/O | ↘ | ↘ | ↗ | | ↗ | | | | | | |

PFI : Port Fuel Injection TWC : Three-way catalyst Blank : No Change
 SIDI : Spark Ignition Direct Injection W : With Thin : A little increase or decrease
 CARB : Carburetor W/O : Without Thick : Increase or Decrease

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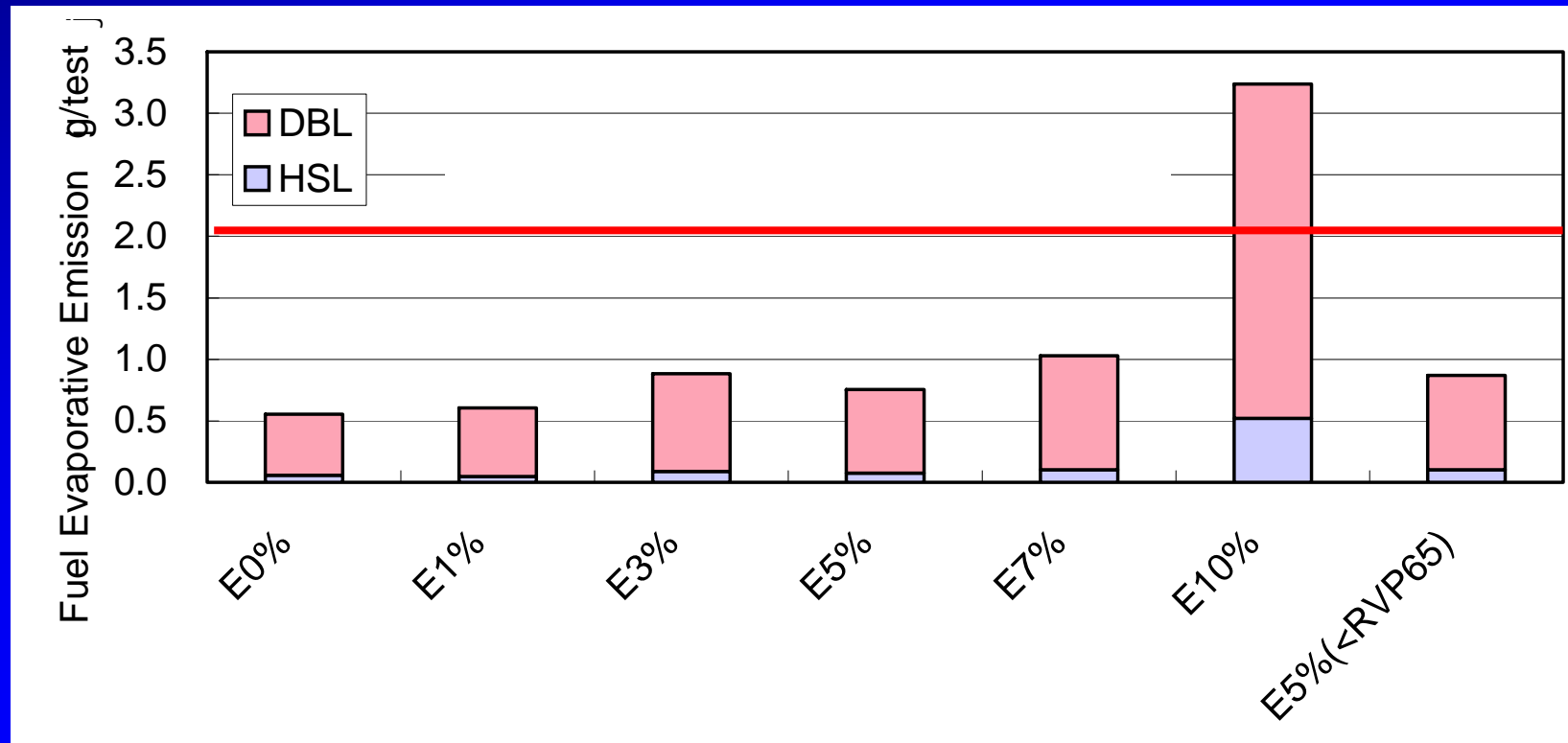
Example of Evaporative Emissions



HSL test and DBL test (New Passenger Vehicle, PFI, TWC)

PFI : Port Fuel Injection
TWC : Three-way catalyst

Example of Evaporative Emissions

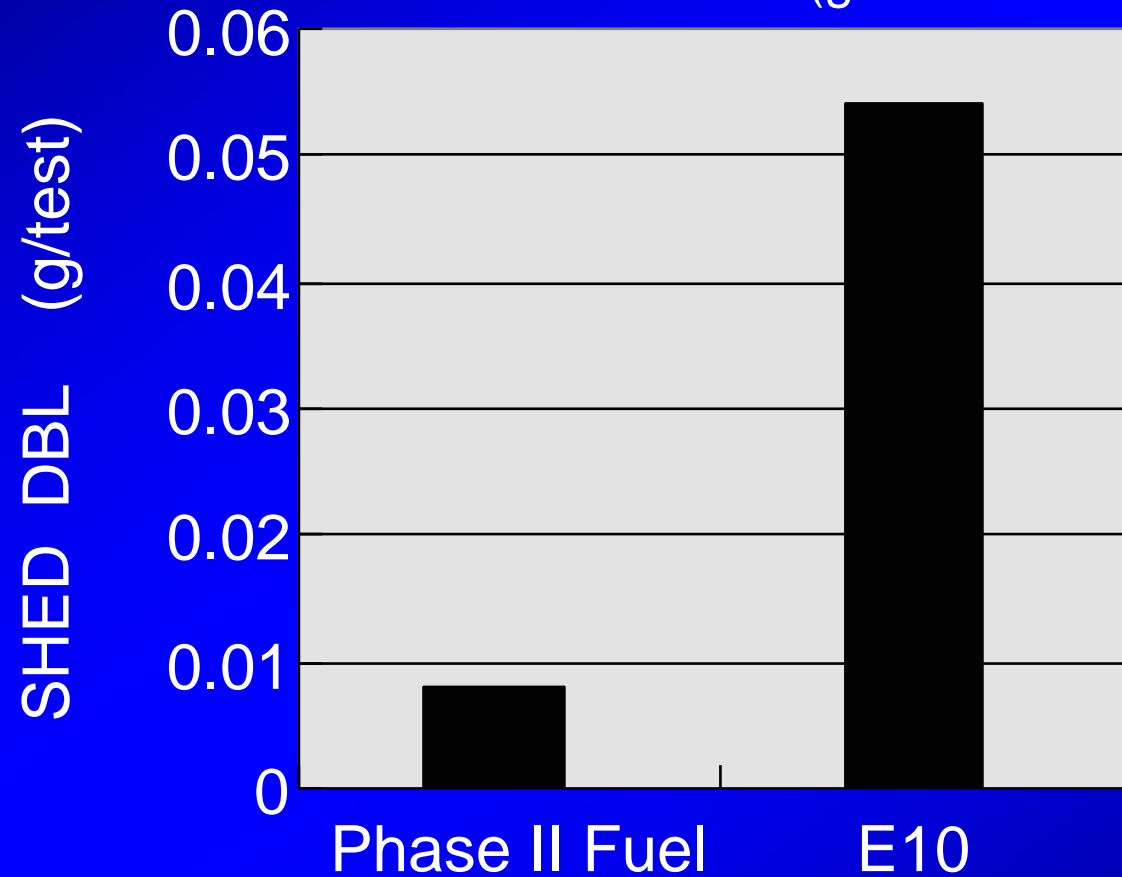


HSL test and DBL test (New Light Vehicle , PFI,TWC)

PFI : Port Fuel Injection
TWC : Three-way catalyst

Permeation of Pump Sender Gaskets

(gasket material : NBR)

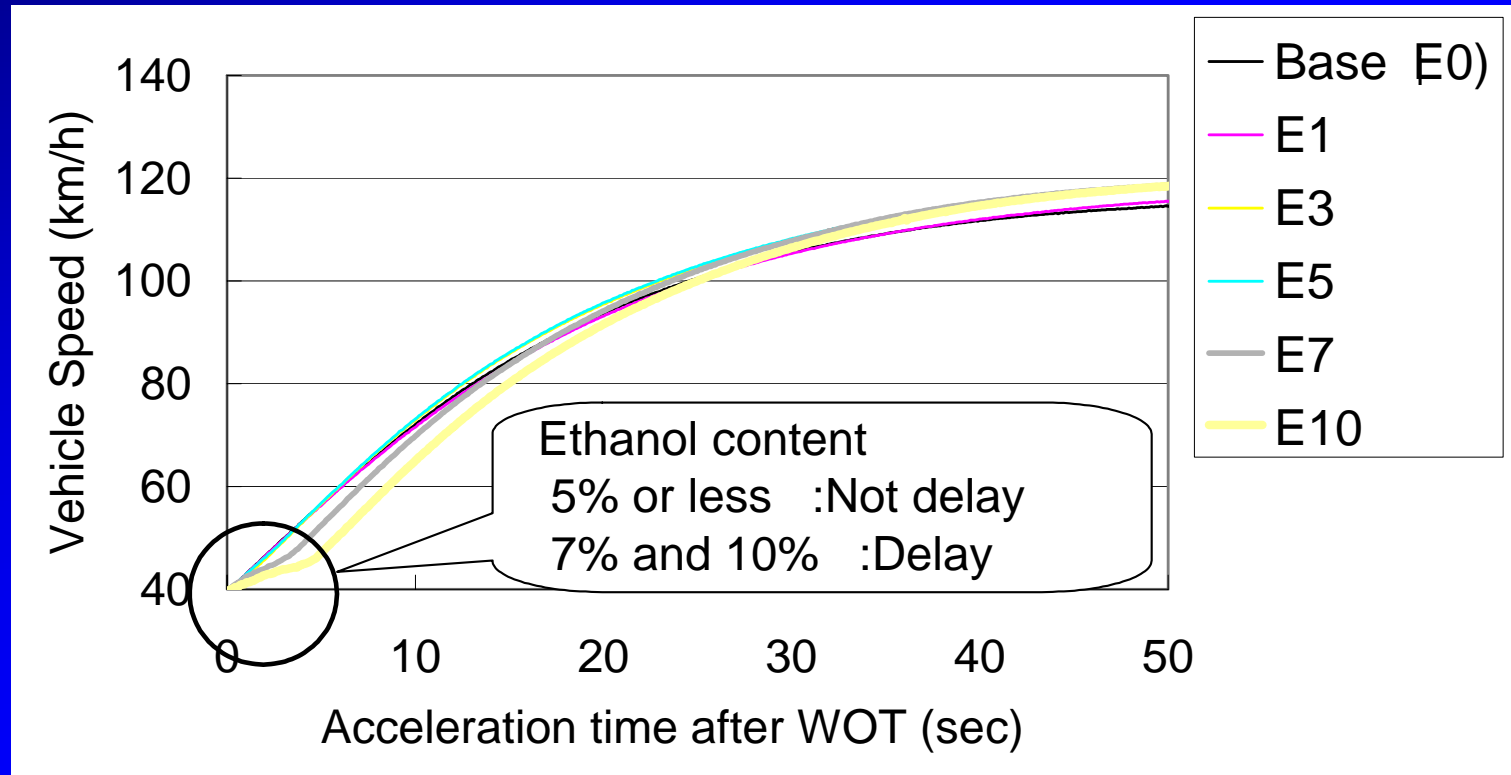


Pre-soak
40 C * 28days

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Effects of Ethanol blending on Driveability



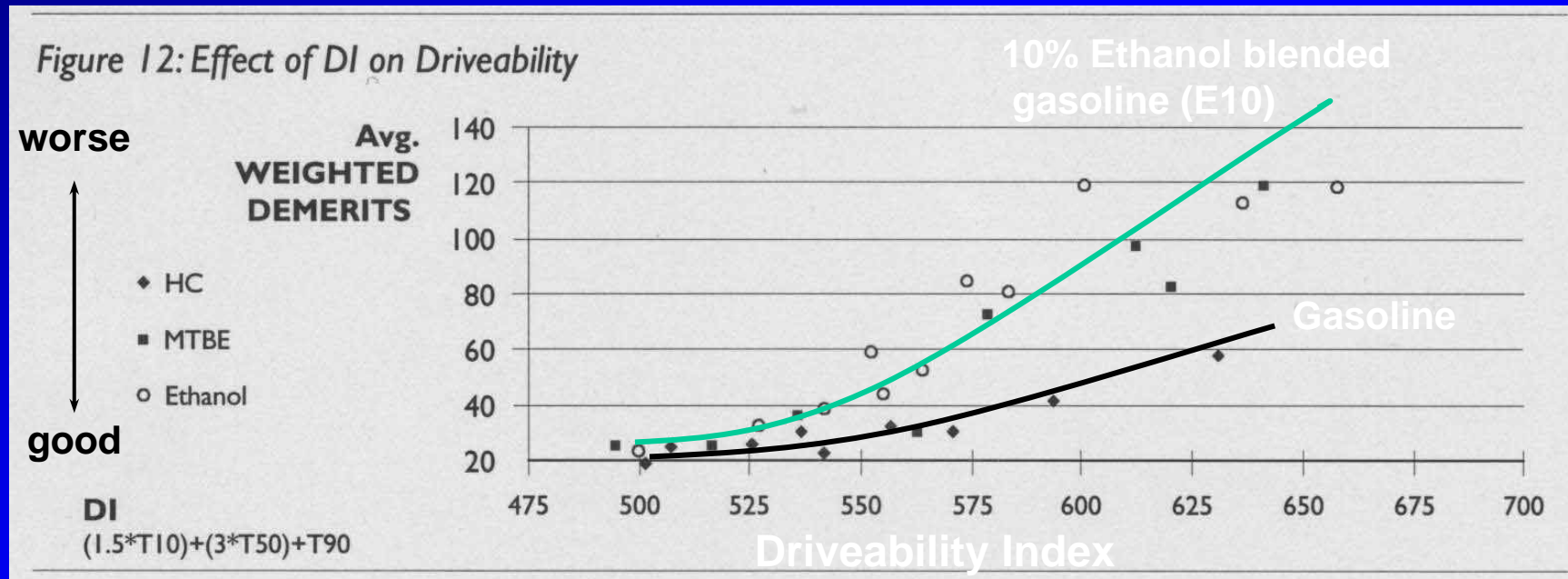
In the relationship between the velocity and the time
(10years Commercial Vehicle, CARB, TWC)

CARB: Carburetor

TWC : Three-way catalyst

WOT : Wide Open Throttle

Effects of E10 on Driveability

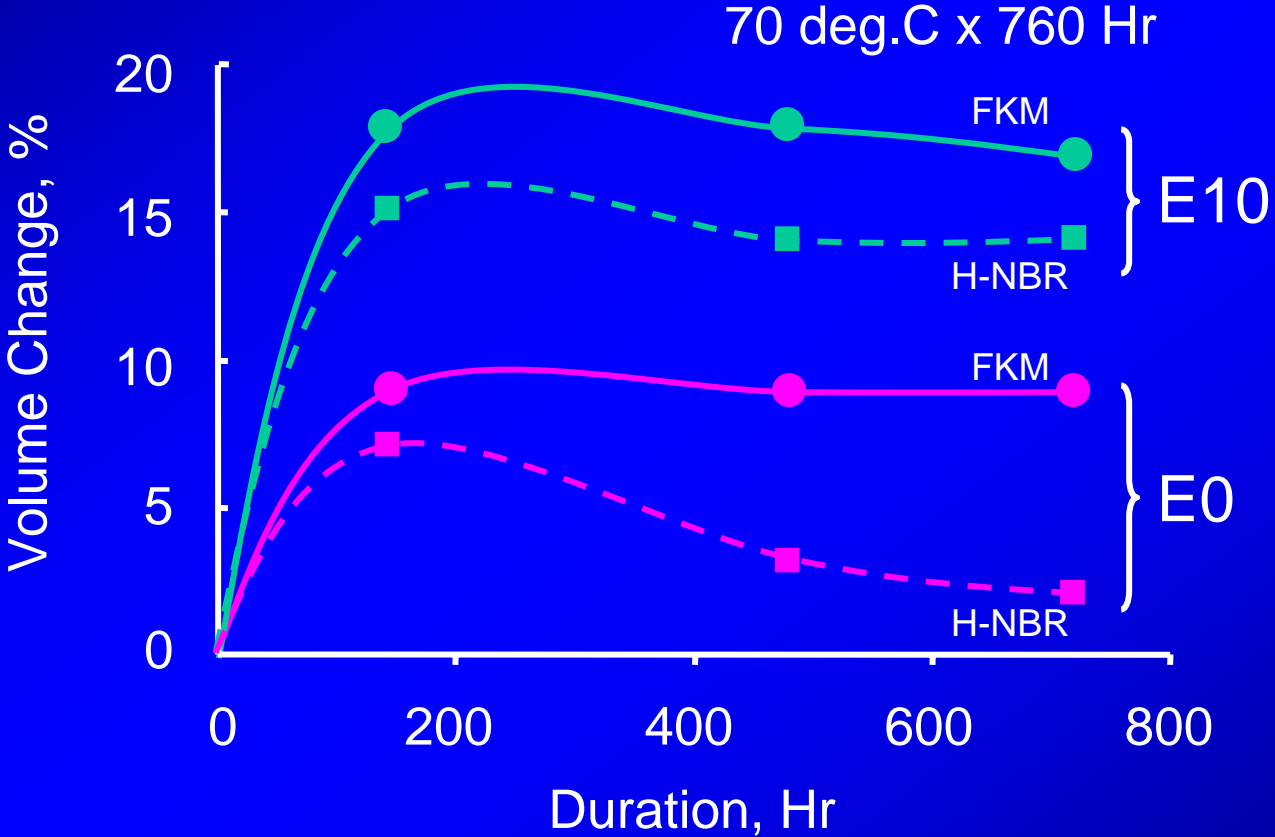


In the case of same driveability index, Ethanol blended gasoline causes worse driveability. Volatility of Ethanol blended gasoline should be controlled very carefully.

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Effects of Ethanol on Elastomer



Effects of Ethanol on Metals

Dry Corrosions

Immersion test results (Test condition : 100 deg.C x 720 Hr)

| Fuel condition | Test piece condition | | Immersion condition | Ethanol content | | | | | |
|----------------|----------------------|----------|---------------------|-----------------|-------|-------|---------|---------|---------|
| | | | | 0% | 1% | 3% | 5% | 7% | 10% |
| Virgin | Single-material | A1050 | in liquid | OK | OK | OK | 27.8 | 59.7 | 100 |
| | | A6061 | in liquid | OK | OK | OK | 8.6 | 5.8 | 18.1 |
| | | ADC12 | in liquid | OK | OK | OK | 41.4 | 39.2 | 27.3 |
| | Bimetallic | Zn/A1050 | in liquid | OK/OK | OK/OK | OK/OK | OK/34.2 | OK/65.4 | OK/100 |
| | | Zn/A6061 | in liquid | OK/OK | OK/OK | OK/OK | OK/8.6 | OK/6.8 | OK/13.0 |
| | | Zn/ADC12 | in liquid | OK/OK | OK/OK | OK/OK | OK/34.8 | OK/30.7 | OK/30.9 |

The number in the table is a ratio of the mass decrease before it immersion (%)

OK No change

* Change in Surface without Reduction in Mass

** Reduction in Mass

*** Completely Dissolution

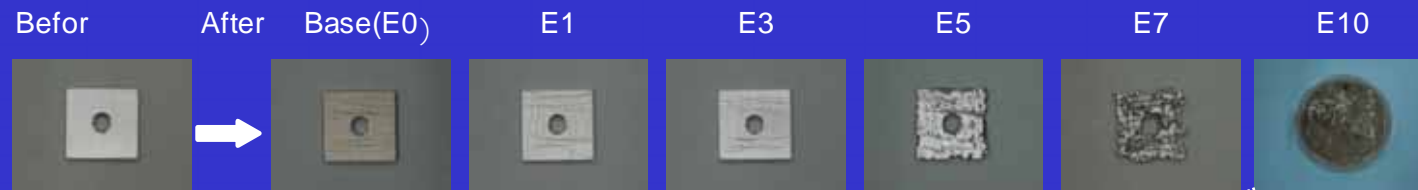
Effects of Ethanol on Metals

Dry Corrosions

Immersion test results

Test condition § Single-material(Scratched in liquid), Water content minimum(Virgin), Immersion in liquid

Material A1050



Complete dissolution

Material A6061



Material ADC12

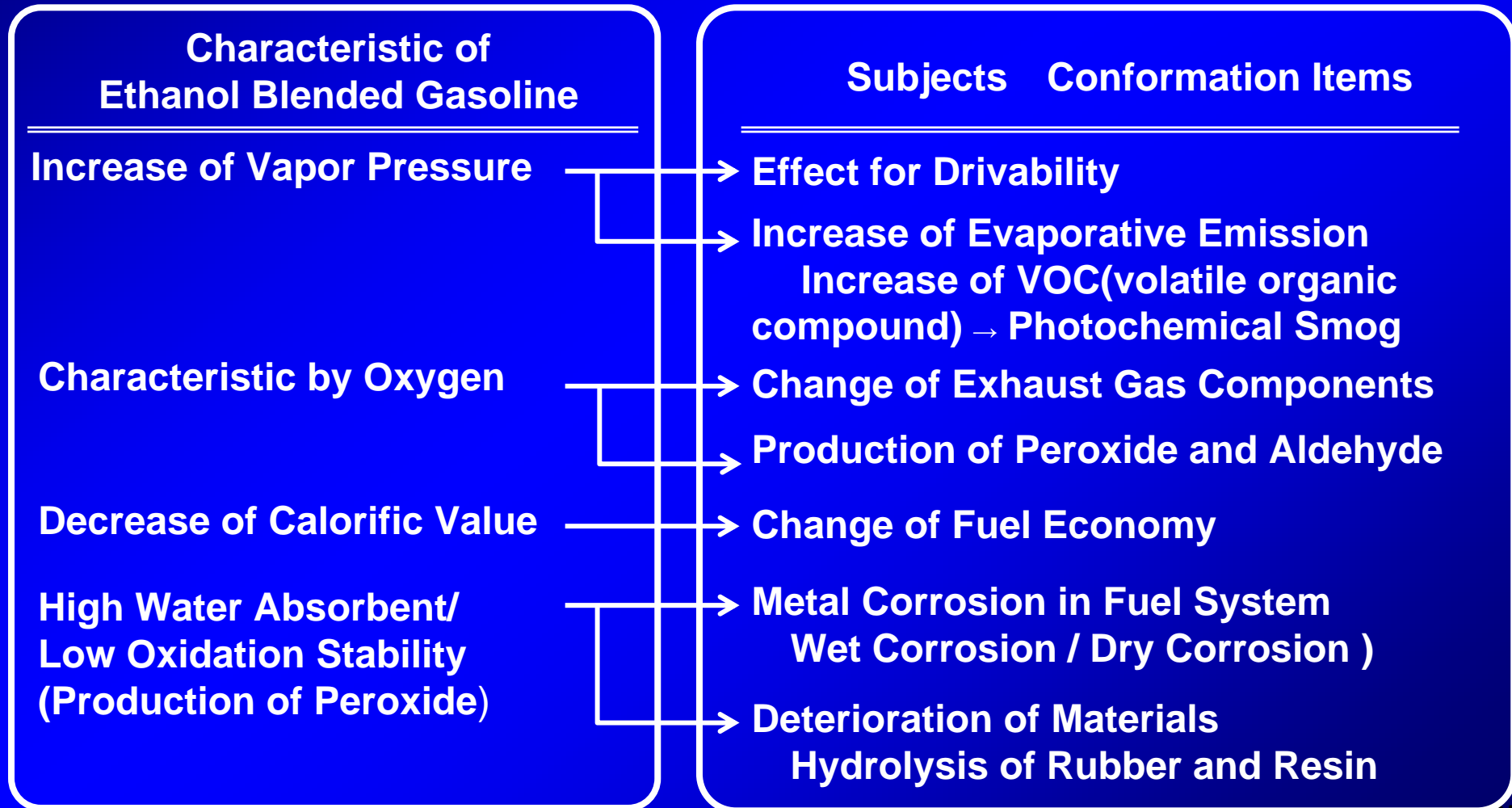


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Effects for Vehicle caused by Ethanol Blended Gasoline

- For vehicles that has already been released in the market, the effects of ethanol must be verified.
- A period of time would be required for the developing and manufacturing of vehicle.



Example of Counter measures for Ethanol Blended Gasoline

Following counter measures are applied as ethanol blending gasoline is used.

- Change fuel system materials (elastomer, metals and plastics)
- Adjust engine control to the gasohol (emissions, driveability)

| Parts | Counter Measure |
|---|---|
| Fuel delivery pipe | Change materials and surface treatment materials |
| High pressure Fuel hose | Change materials |
| Low pressure Fuel hose | Change materials |
| Related evaporative emissions (Hose, O-ring, Gaskets) | Change materials |
| Fuel metal tube | Change materials and surface treatment materials |
| Functional components pressure regulator, pulsation damper) | Change materials and surface treatment materials |
| Engine control system | Adjusting air fuel ratio control, the control of fuel pressure and injector tip temperature to ensure the exhaust emissions and driveability. |

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Summary

1. Ethanol has several negative impacts on vehicle performances. When using ethanol for gasoline as one of alternative fuel, review of fuel specifications and good housekeeping are necessary to prevent the deterioration of air quality and market problem.
2. And lead time of introducing the vehicles adapted for ethanol blending gasoline and 2-dispenser system to avoid fueling ethanol blend to the vehicles existing in the market are also necessary.

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Basic Position of JAMA on Ethanol

JAMA will not oppose the blending of ethanol as far as the following conditions are met:

- ***Adequate specifications***

for ethanol-blended gasoline and
for the ethanol as blending stock

- ***Good house keeping***

(Ethanol easily adsorbs water, therefore quality control
in distribution system is important)

- ***Fuel Quality Monitoring System (FQMS)***

to ensure the quality of the fuel at pump.

Basic Position of JAMA on Ethanol

- ***Countermeasures for non E10 vehicles***

Some vehicles in the market are not applicable for E10. **Lead time** and/or **two dispenser system** should be considered in a such case.

- ***Up to 10v% of ethanol***

E10 has been used in the US since mid of 1970's.

Vehicle technologies for E10 are available as far as the requirements for emissions are same level as that in the US.

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JAMA's Recommendation

- JAMA recommend that New Zealand government will adopt Japanese specification (up to 3% of ethanol) because currently over 50% of gasoline vehicles in New Zealand is Japanese domestic model (used imported vehicles).
- Two pump system with fuel pump label will be desirable if New Zealand government select the implementation of higher than 3% of ethanol with some reasons.
- RVP of summer gasoline (70 and 75 kPa max) could be reviewed to avoid the trouble in the market.