

U.S. Biofuels – Motor Vehicle and Engine Technology

**Dr John Bennett
Ford Motor Company**

**ASEAN-U.S. Enhanced Partnership
Biofuels and the Automotive Industry Seminar**



Auto-industry engagement

- Automotive industry supports the increasing use of biofuels to reduce dependency on mineral oil and address environmental concerns.
- Vehicle technology cannot solve these in isolation; need *Integrated Approach*, incorporating renewable fuels.
- ***However, existing customers must be continue to be supplied with suitable fuels for their vehicles***



Biofuel markets

- Biofuel markets are becoming global.
- Various markets have differing levels of experience.
 - Experience with Ethanol mainly in US and Brazil (the 2 biggest markets).
 - Experience with Biodiesel mainly in EU (the biggest market)



Ethanol Blends - Vehicle Application

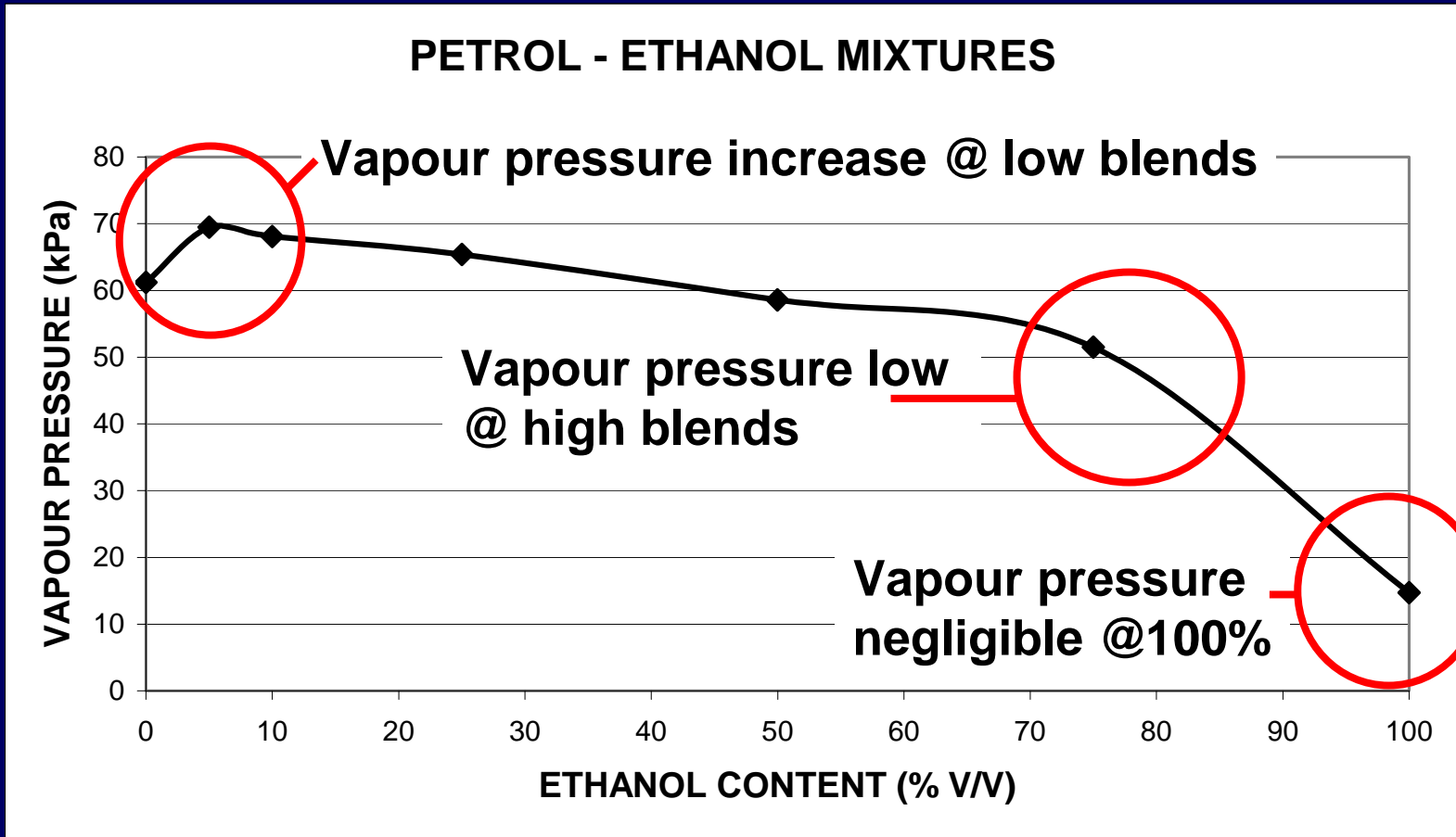
- **E5** – All vehicles
 - **E10** – US market + recent EU vehicles
 - **E20** – Market specific vehicles with some flex capability
 - **E85** – Full flex-fuel capability required
 - Operation transparent to customer
- *Flex-Fuel Vehicle (FFV): Can use 0% to 85% ethanol - gasoline blends with a single fuel tank.*

Key Ethanol Properties vs. Gasoline

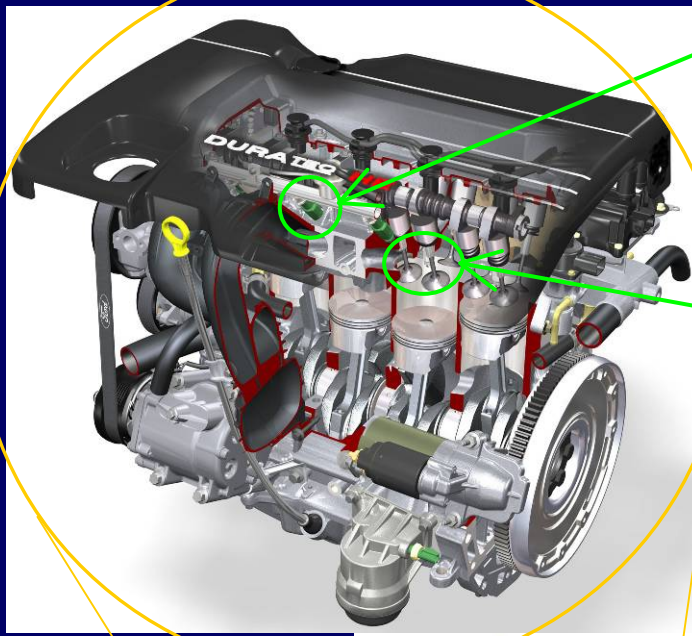
- Affects vapor pressure
 - Low blend may have increased vapour pressure **if not controlled**
 - Vapor-lock / hot fuel handling risk
 - Increased evaporative emissions => degraded air quality
 - High blend may have inadequate vapour pressure
 - Difficult starting / cold drive
- High octane (E85 = ~105 RON)
 - Requires ignition timing remapping
 - Some potential to increase engine efficiency
- High latent heat
 - Potentially degraded cold driveability : adapt engine calibration
 - Some potential to increase engine efficiency
- Low energy content (calorific value)
 - Increased fuel flow requirements
 - Larger fuel system components
 - Fuel injection mapping requires adaption
- Corrosive
 - Corrosion resistant materials and components in fuel system



Vapour pressure of ethanol – petrol blends



Data courtesy CLH, Spain



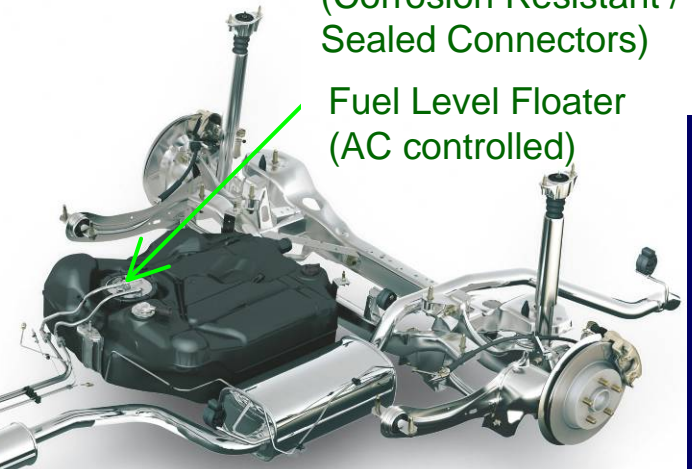
Injectors with Increased Flow Rate (Corrosion Resistant)

Hardened Valve Seats

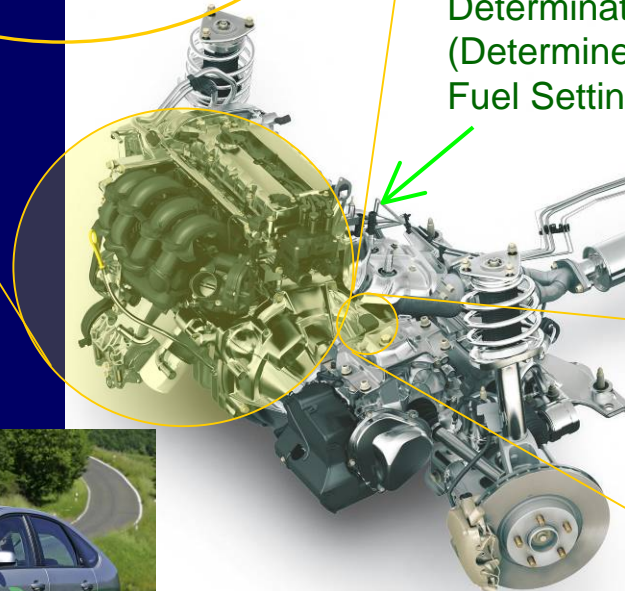
Tank Fuel Pump (Corrosion Resistant / Sealed Connectors)

Fuel Level Floater (AC controlled)

Heated Lambda Sensor Utilized for EtOH Concentration Determination (Determines Spark & Fuel Settings)



Fuel Bundle Corrosion Resistant



Engine Block Heater for cold climates



Advanced Partnership - Biofuels and the Automotive Industry Seminar
Siam City Hotel, Bangkok, October 24, 2007

Feel the difference



Ethanol Energy Content

- Ethanol has 35% less energy than gasoline
- Fuel consumption proportionally increased
- Noticeable to customers at high blend levels
- Requires high flow fuel system
- ***Requires offsetting fuel price!***



Ethanol Market Experience – Brazil

- Brazil has the worlds highest per vehicle consumption of ethanol.

BUT

- Has unique ethanol blend composition.
- Not a good benchmark case for globally aligned ethanol market development.



Ethanol Market Experience – Brazil

Why is it unique?

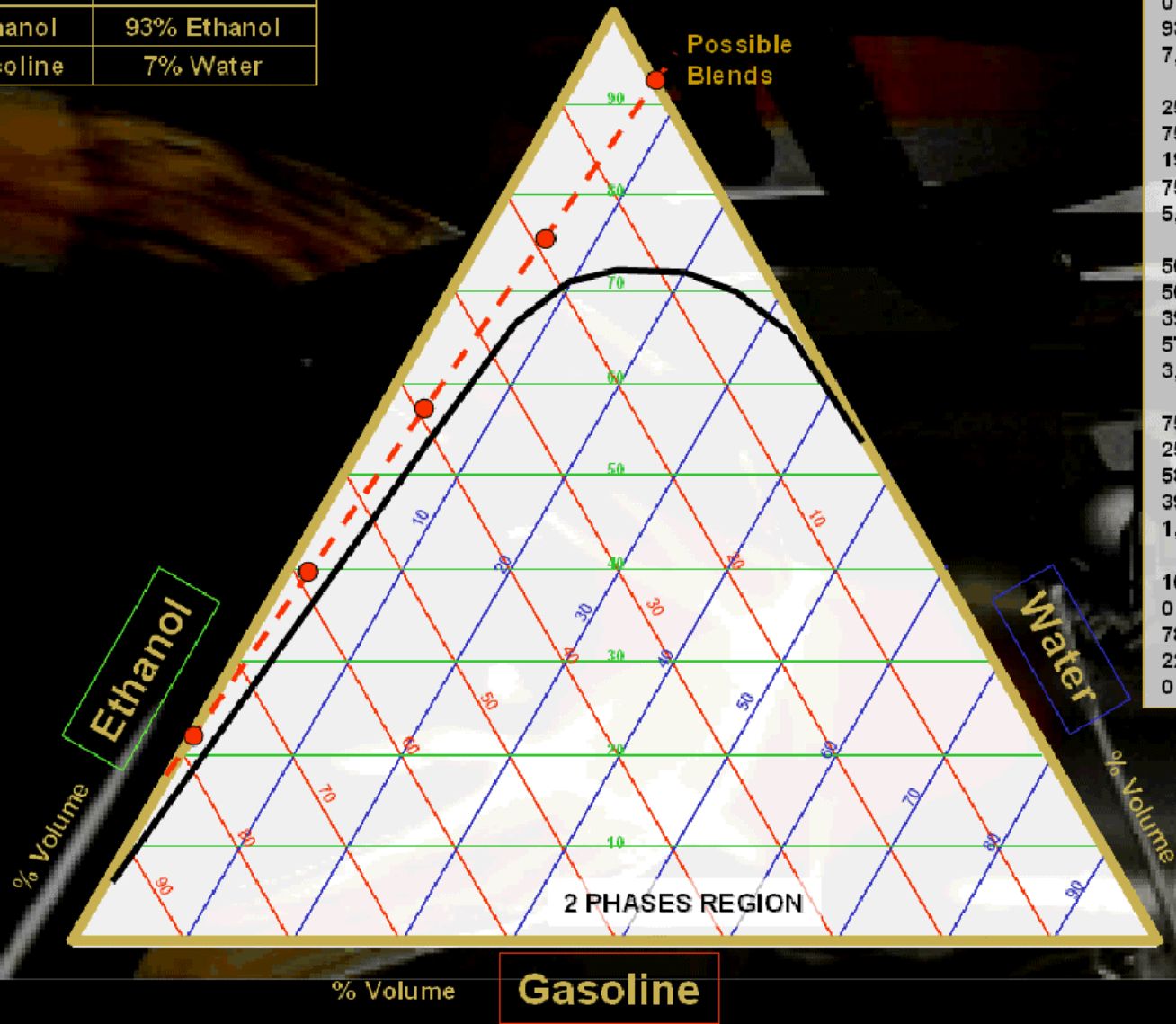
Two fuel grades:

- Gasohol (gasoline – ethanol) E22 – E25 (varies)
 - Made using **anhydrous** ethanol
- Alcohol
 - Ethanol E93 **Hydrated** (approx 7% water)
- Both can be used in Brazil market Flex Fuel vehicles
- Water in E93 requires ALL gasoline must have some ethanol content to avoid phase separation
- No gasoline in E93 = very low vapour production
 - Absence of gasoline requires secondary fuel supply to enable starting.



Difficulties: Miscibility

Gasoline – E22	Ethanol – E100
22% Ethanol	93% Ethanol
78% Gasoline	7% Water



- Another Examples:**
- 0% E22
 - 100% E100
 - 0% Gasoline
 - 93% Ethanol
 - 7,0% Water
-
- 25% E22
 - 75% E100
 - 19,5% Gasoline
 - 75,25% Ethanol
 - 5,25% Water
-
- 50% E22
 - 50% E100
 - 39% Gasoline
 - 57,5% Ethanol
 - 3,5% Water
-
- 75% E22
 - 25% E100
 - 58,5% Gasoline
 - 39,75% Ethanol
 - 1,75% Water
-
- 100% E22
 - 0% E100
 - 78,0% Gasoline
 - 22,0% Ethanol
 - 0% Water

Values at 24°C



Brazil FFV starting fuel tank



Biodiesel Technical Considerations

- Vehicle manufacturers approve up to 5% biodiesel
- Fuel Injection Equipment only approved up to 5% according to **EN14214**
 - Demand for 10% under review
- Biodiesel is aggressive with some elastomers and metals, but can be accounted for by material selection
 - Higher percentages may be concern for older vehicles.
- **Significant concerns about lack of fuel stability**
 - Biodegradable
 - Oxidises much more readily than mineral diesel
 - Becomes corrosive and forms polymers
 - **Main limiting factor for FIE warranty positions**

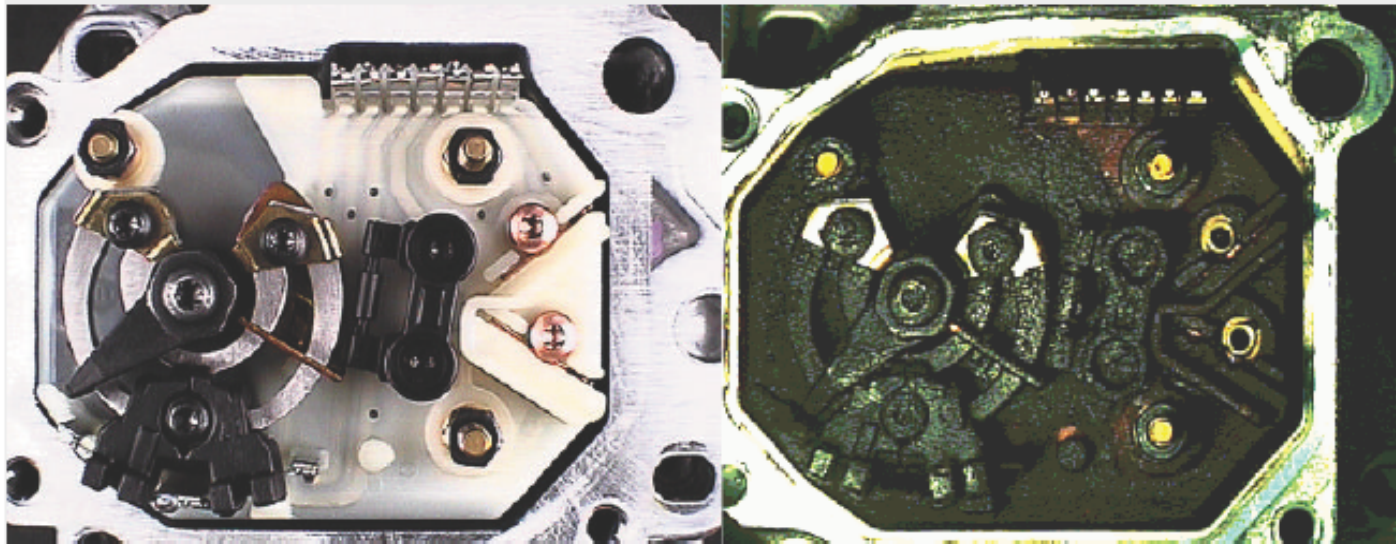
Biodiesel degradation



FAME and FIE

BOSCH

2.1. Deposit Formation by Precipitation of Ageing Products (1)



Distributor pump VP37: Setting mechanism after operation with RME of insufficient quality

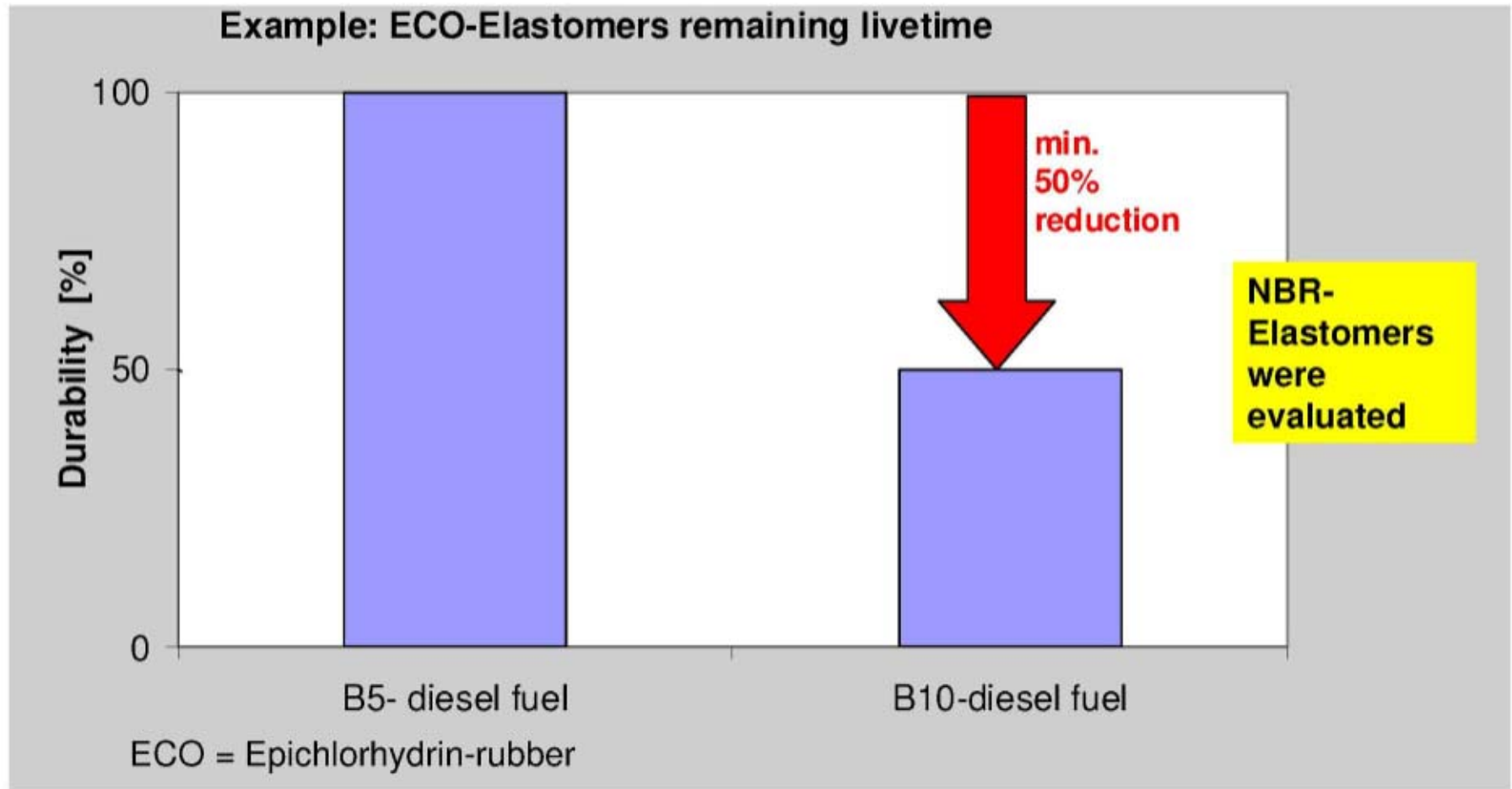
Biodiesel Technical Considerations (cont.)

- Material compatibility issues
 - Aggressive against certain metals and elastomers
- Higher solvency
 - Scouring effect on older fuel storage systems
- Higher water dissolving
 - Can deactivate water coalescers
- Approx 10% lower calorific value than mineral diesel (oxygenate)
 - Slightly increased fuel consumption
- Waxes more readily than mineral diesel
 - Concerns about cold flow
- **Significant concerns about suitability for use with Diesel Exhaust Particulate Filters used in latest technology vehicles**
 - Fuel into Oil dilution
 - Post-injection used to regenerate DPF's
 - Ash levels may be increased
 - Heat release during regeneration may change

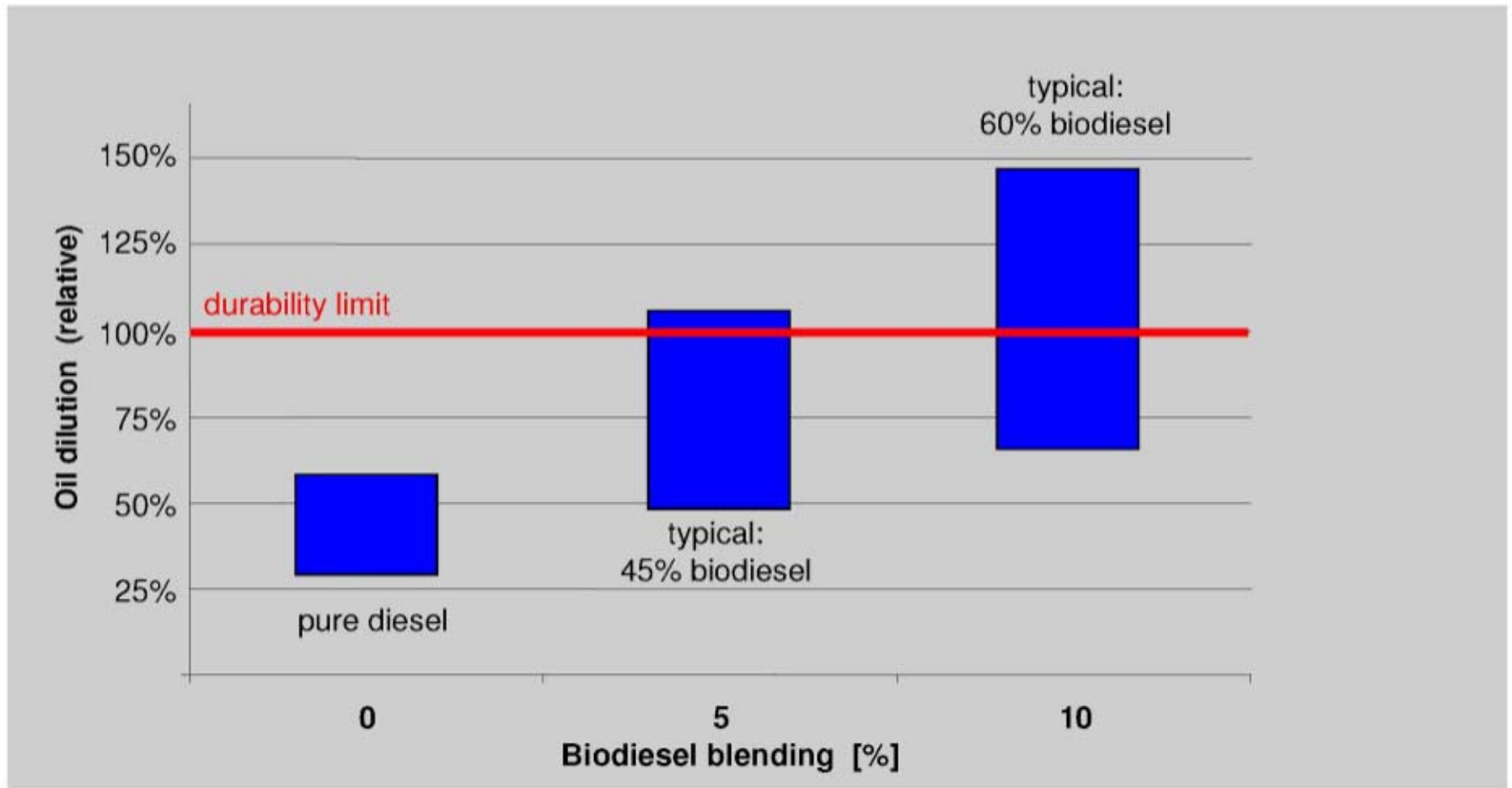


Highlights from VDA presentation to CEN

Unfit materials, existing car population
Impact of 5 und 10% biodiesel blending



Oil dilution from biodiesel blends, Vehicles with DPF-exhaust equipment



VDA Arbeitskreis Betriebsstoffe

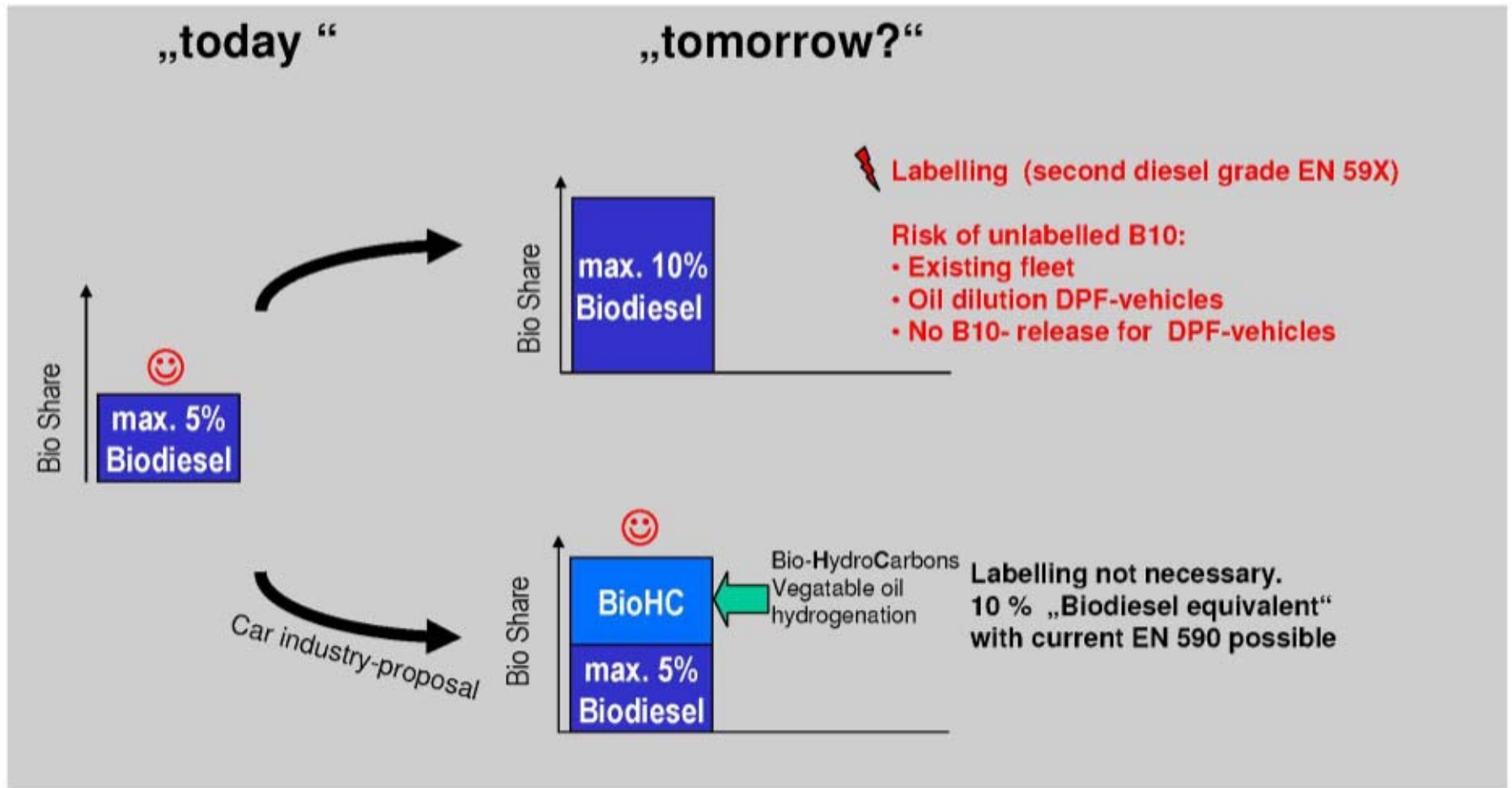
Impact of a higher biodiesel content in the engine oil

- negative impact on tribological system
- too high stress for the additive package
- Deposit forming
- Damages of the catalytic converter



Deposit forming in the piston ring area

Increase of the biomass share in diesel fuel EN 590



VDA Arbeitskreis Betriebsstoffe

1437 05.12.2006

Folie 6

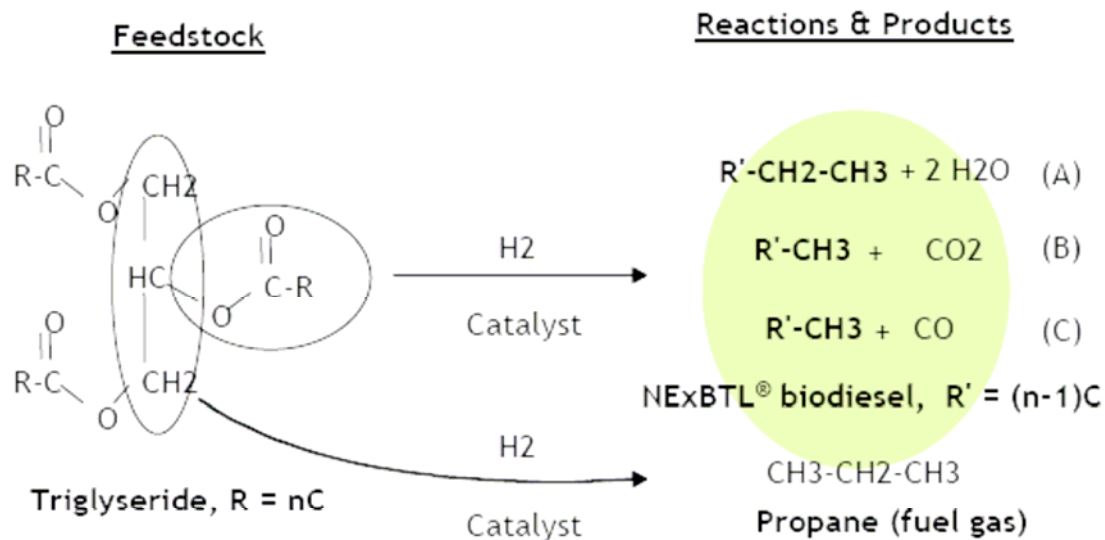
Hydrogenated Vegetable Oils / BTL

- Manufacture of high quality middle distillate from vegetable oils / biomass by hydrogenation or Fischer-Tropsch process (Biomass to Liquid)
- High quality product
 - High cetane (approx 70 vs mineral 51+)
 - Low sulphur
 - Excellent blending component
- ***Vehicle manufacturer preferred***



Hydrogenated Vegetable Oil processing

Simplified NExBTL® Process Chemistry

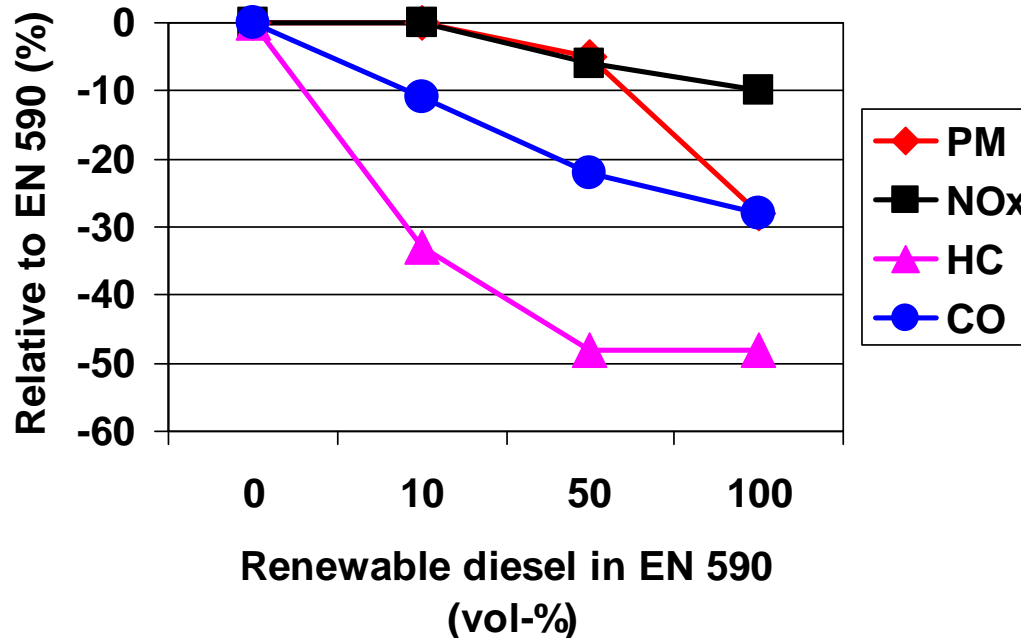


NExBTL® is a stable and pure hydrocarbon!

Figure 2: The new Neste Oil's NExBTL® Renewable Diesel Technology to produce a second generation renewable diesel.

Source: Neste Oil

Emissions Benefits of HVO



Reduction in vehicle emissions at increasing concentrations of renewable diesel in petroleum diesel (EN 590).

Source: MAN, 5th Colloquium of Fuels, Esslingen, January 2005

Unmodified Vegetable Oils

- **NOT acceptable in ANY concentration.**



Conclusions

- Existing vehicles must be accounted for when introducing biofuels.
- Vehicle technology to accommodate ethanol blends is well understood
- Appropriate market fuel quality is required
- Vehicle technology may not be capable of using higher blends of biodiesel
- Renewable diesel can be made via alternative routes such as hydrogenation / BTL

