Brazilian experience in ethanol fuel: quality aspects and distribution logistics

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Outline

- Introduction
- Ethanol/Sugar Cane Industry
- Current Logistics
- Future Logistics
- Ethanol Quality

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Introduction

The reduction in the availability of fossil fuel is a growing concern. This fact has made the search for alternative fuel (biofuel) sources increasingly important.

The dominant biofuel in many countries is ethanol. Ethanol has been used as blend component in gasoline or as pure fuel.

Thus, ethanol quality at the distribution system is routinely required.

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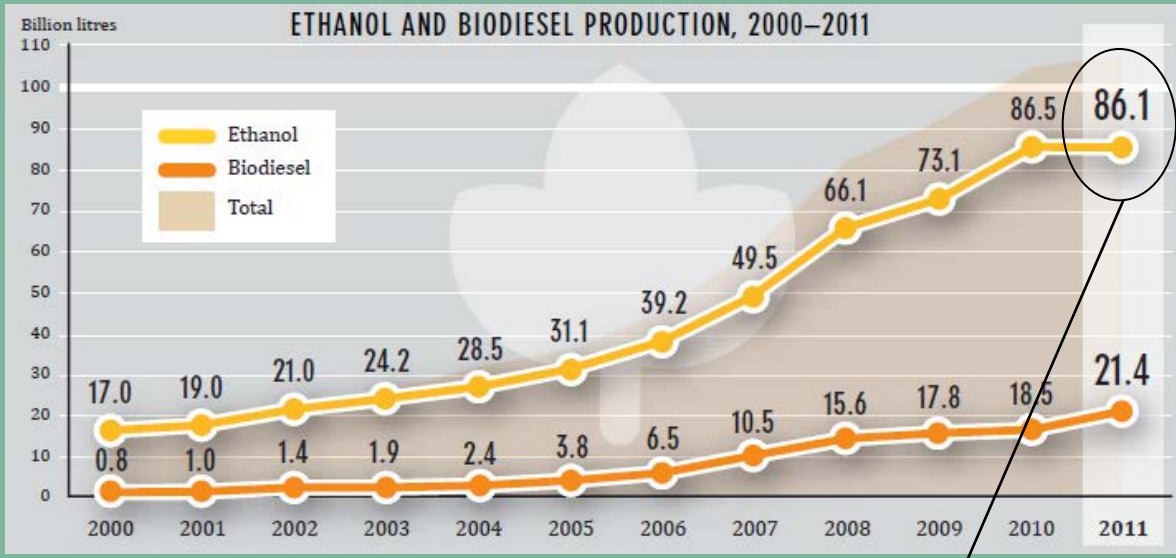
Introduction

✓ Biofuels energy share of global final energy consumption (2010): 0.7%

✓ Biofuels usage of global road transport (2011): 3%



	Ethanol production 2011	86.1 billion liters
1	United States	63%
2	Brazil	24%
3	China	
4	Canada	
5	France	

Source: Renewables 2012 Global Status Report

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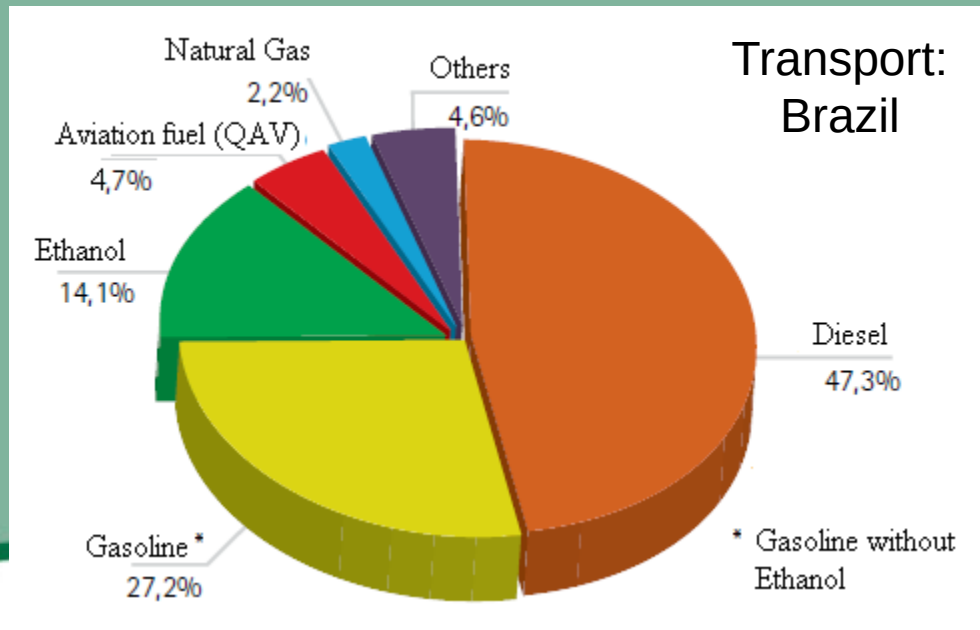
Ethanol/Sugar cane Industry:
Brazil

- ✓ Ethanol suppliers = 514 (10/2012) (1)
- ✓ Area planted = around 10 millions of hectare; less than 1% of Brazil total area (2011/2012)
- ✓ Participation in the Brazilian energy matrix (2011) = 4.7% (ethanol) 11.9% (bagasse) (2)



Note: Road Transport – AE 8.4 % HE 12.2 %

(1) www.anp.gov.br
(2) https://ben.epe.gov.br/

Ethanol/Sugar cane Industry:
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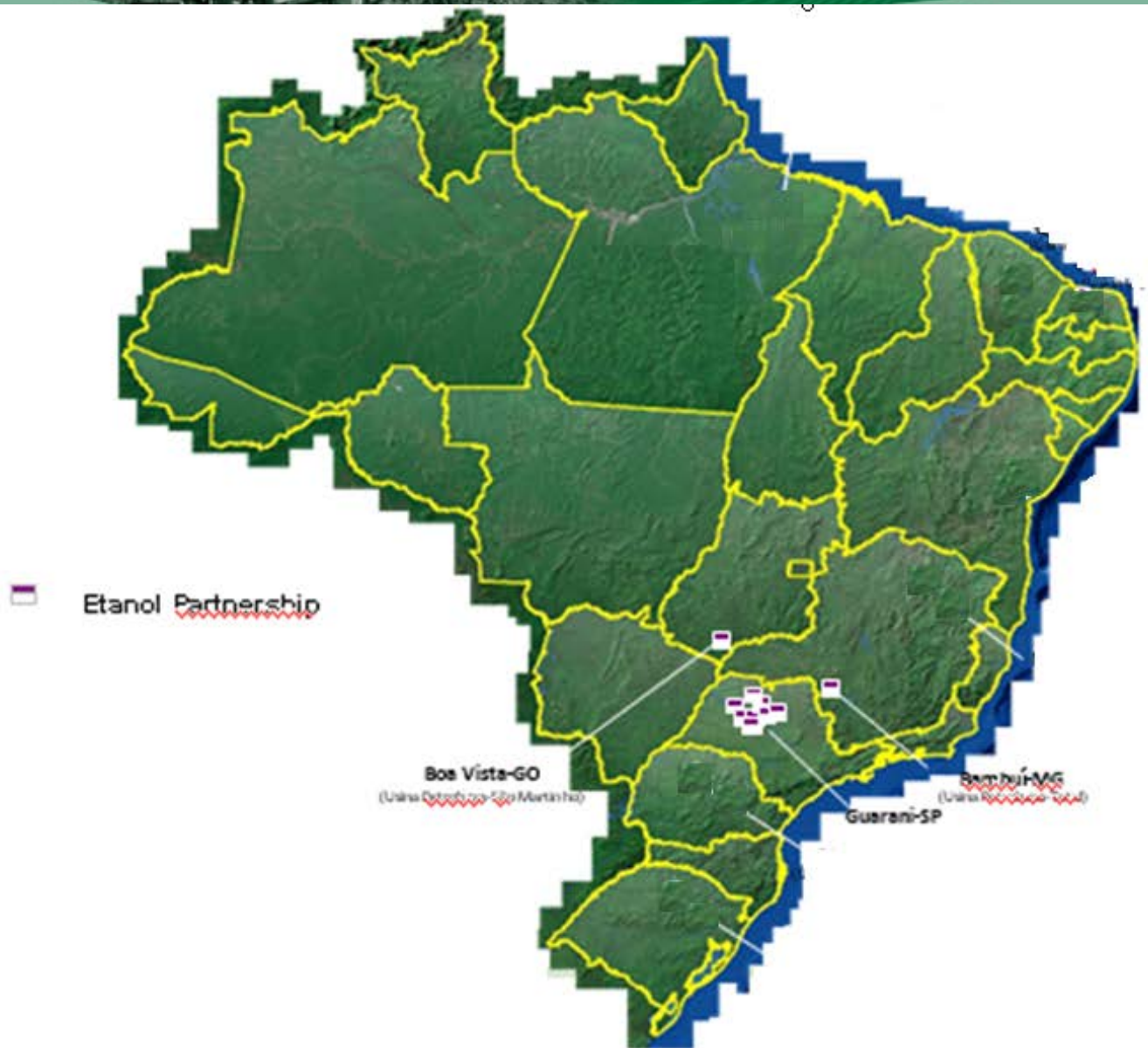

10 units:

√ **Guarani (Tereos): 7 SP and 1 Mozambique**

√ **Total Agroindustria: Bambuí/MG**

√ **Nova Fronteira BioEnergia (Group São Martinho): Quirinópolis/GO**

Total production: 1.3 billion liters of ethanol per year

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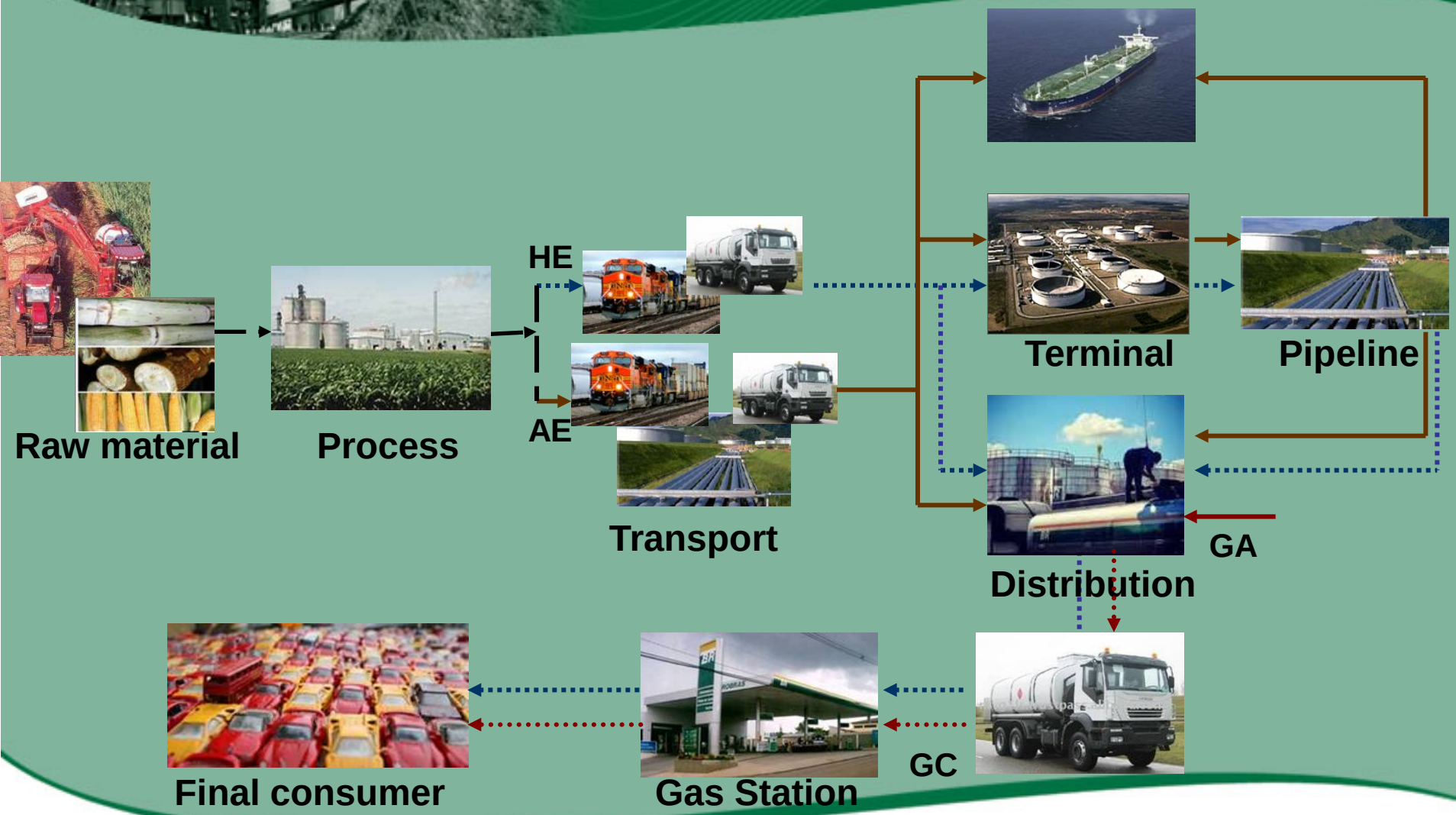
Current Logistics



HE = hydrous ethanol (<7.5%m/m H_2O, to use as straight fuel); AE = anhydrous ethanol (<0.7%m/m H_2O, to blend in gasoline) ; GC = Gasoline with AE

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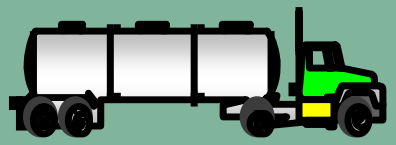
Current Logistics:
Road Transport



Around 90% of ethanol is transported by road

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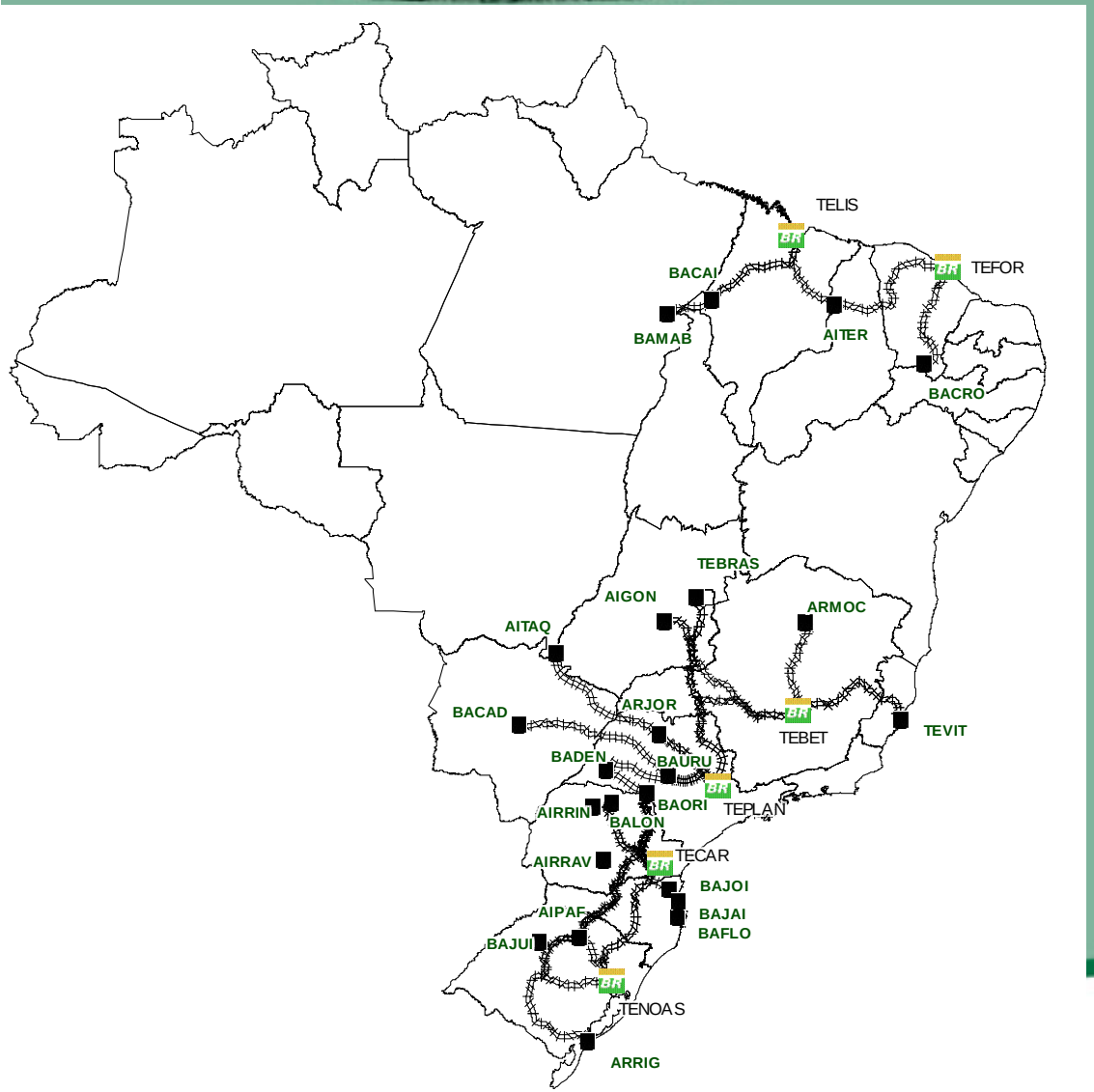
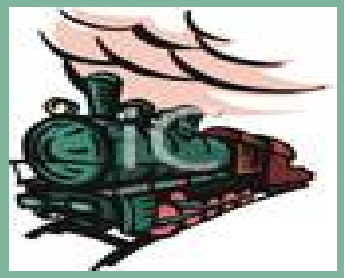
Current Logistics:
Railroad Transport





Practically used as
“return freight”

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Current Logistics:
Pipeline

Pipeline – 7,100 km (different liquid fuels) – 876 km (ethanol)

Pipelines are not exclusive for ethanol (for ex. OPASA-99 km, OSRIO-512 km, OPASC-266 km).

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Future Logistics:
Logum

Logum Logistics SA (since March 2011) - responsible for the construction and operation of the Ethanol Logistics System (logistics, loading, unloading, handling and storage, operation of ports and onshore terminals and waterways) that involve multimodal transport: pipelines, waterways (barges), highways (trucks) and coastal (vessels).

Logum forecasts the creation of pipelines and waterways which will operate in conjunction with the existing distribution system.

The project is being funded by BNDES, and is part of the PAC - Growth Acceleration Program - sponsored by the Federal Government.

Future Logistics:
Logum

Pipeline – 1,300 km ; Storage – 1.2 billion liters of ethanol ;

Capacity to transport up to 21 billion liters (21 millions m^3) of ethanol per year

Future Logistics:
Logum

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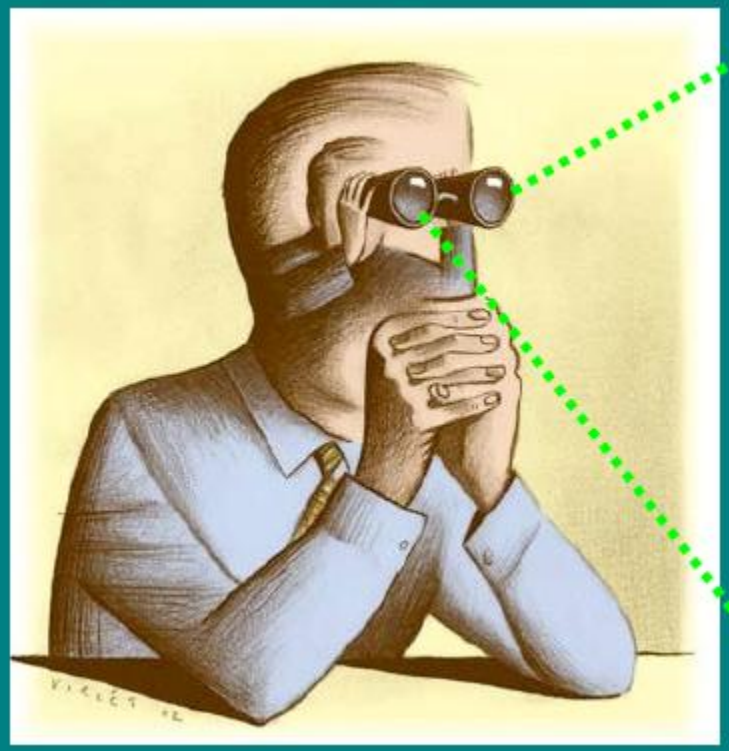
Ethanol Quality



Monitoring of ethanol storage, transport and distribution is important to keep the ethanol quality till the final consumer.

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Ethanol Quality

To monitor the ethanol quality, some fuel sampling points are indicated:

✓ storage tanks

✓ pipelines (at pumping units - beginning, middle and end of pumping ethanol)

✓ gas station

✓ ship, if applicable

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Brazilian Ethanol Specification (Res. ANP nº 7, 9.2.2011)

Characteristics		Anhydrous Ethanol (EAC)	Hydrous Ethanol (EHC)	Analytical Method
Appearance	-	Limpid	Limpid	Visual
Color	-	Orange with dye*	Without dye	Visual
Total Acidity (as acetic acid)	mg/L	≤ 30	≤ 30	NBR-9866 (or 16047)
Electrical Conductivity	µS/m	≤ 350	≤ 350	NBR-10547
Density (20ºC)	kg/m³	≤ 791.5	≥ 807.6 and ≤ 811.0	ASTM D-4052 NBR-5992
Alcohol Content	% m/m	≥ 99.3	≥ 92.5 and ≤ 93.8	NBR-5992 or 15639
	% v/v	≥ 99.6	≥ 95.1 and ≤ 96.0	
Ethanol Content .	% v/v	≥ 98.0	≥ 94.5	ASTM D-5501 (or NBR 16041)
Hydrogen ionic Potential (pH)	-	Not specified	≥ 6.0 and ≤ 8.0	NBR-10891
Water Content .	% v/v	≤ 0.4	≤ 4.9	NBR-15531 or 15888
Methanol Content .	% v/v	≤ 1	≤ 1	chromatography (or NBR 16041)
Evaporation Residue ..	mg/100mL	≤ 5	≤ 5	NBR-8644
Hydrocarbons Content ..	% v/v	≤ 3	≤ 3	NBR-13993
Ion Chloride (Cl^-)	mg/kg	≤ 1	≤ 1	NBR- 10894
Ion Sulphate (SO_4^{-2}) …	mg/kg	≤ 4	≤ 4	NBR- 10894
Iron (Fe) …	mg/kg	≤ 5	≤ 5	NBR-11331
Sodium (Na) …	mg/kg	≤ 2	≤ 2	NBR-10422
Cupper (Cu) …	mg/kg	≤ 0.07	Not specified	NBR-11331

* all anhydrous ethanol must have an orange dye (15 mg/L) to prevent water adulteration.

Characteristics		Vehicle Performance	Vehicle Protection	Fuel Quality Control
Directly Specified	Indirectly Specified			
Appearance				Transport Contamination
Color				Transport Contamination
Total Acidity			Corrosion	Production Quality and/or Transport Contamination
Electrical Conductivity			Corrosion & Deposit Formation	Production Quality and/or Transport Contamination
Density		Drivability (Air/Fuel Ratio)		
Alcohol (Ethanol) Content		Drivability (Air/Fuel Ratio)		Transport Contamination
Hydrogen ionic Potential			Corrosion	
Water Content		Drivability & Fuel Consumption	Corrosion	Production Quality and/or Transport Contamination
Methanol Content		Fuel Consumption (Energy Content)		Transport Adulteration
Evaporation Residue			Deposit Formation	Transport Contamination
Hydrocarbons Content				Transport Contamination
Ion Chloride (Cl^-)			Corrosion	Transport Contamination
Ion Sulfate (SO_4^{-2})			Corrosion & Deposit Formation	Production Quality
Iron (Fe)			Deposit Formation & Wear	
Sodium (Na)			Corrosion & Deposit Formation	Production Quality
Cupper (Cu)			Deposit Formation (Catalyzes the gasoline oxidation)	
	C3 – C5 Alcohols Content	Fuel Consumption (Energy Content)		

Ethanol Quality:
Main parameters

Producer/Provider (Quality Certificate) [7,10,11]

- ✓ Color and Appearance
- ✓ Total Acidity
- ✓ Electrical Conductivity
- ✓ Density
- ✓ Alcohol Content
- ✓ pH
- ✓ Sulfate Content
- ✓ Iron Content
- ✓ Sodium Content
- ✓ Cupper Content

Distribution (Accordance Bulletin) [6,8,9]

- ✓ Color and Appearance
- ✓ Electrical Conductivity
- ✓ Density
- ✓ Alcohol Content
- ✓ pH
- ✓ Evaporation Residue *(pipeline – waterway transport)*
- ✓ Hydrocarbons Content *(pipeline – waterway transport)*
- ✓ Chloride Content *(waterway transport)*

Pipelines and trucks (extra) [5]

- ✓ Color and Appearance
- ✓ Density
- ✓ Alcohol Content
- ✓ Hydrocarbon Content

Importation

- ✓ Resolution ANP nº7, 9.2.2011

Note: Water, Ethanol, Methanol Content are done in case of quality doubt

ANP (Agência Nacional do Petróleo, Gás Natural e Biocombustíveis)

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Ethanol Quality:
Phase separation

Ethanol-gasoline blends are more likely to phase separate : "ethanol-water vs. gasoline"

Factors that affects phase separation: *Ethanol amount, gasoline composition (olefins and aromatics), temperature*

Tanks and pipelines must be cleaned before receive ethanol

To minimize the risk of water-induced phase separation of ethanol-gasoline blends, anhydrous ethanol is blended into gasoline at the distribution terminal, closest to the gas station as possible, rather than distributing it through pipelines *(never ships any blended fuel in pipelines, only ethanol)*

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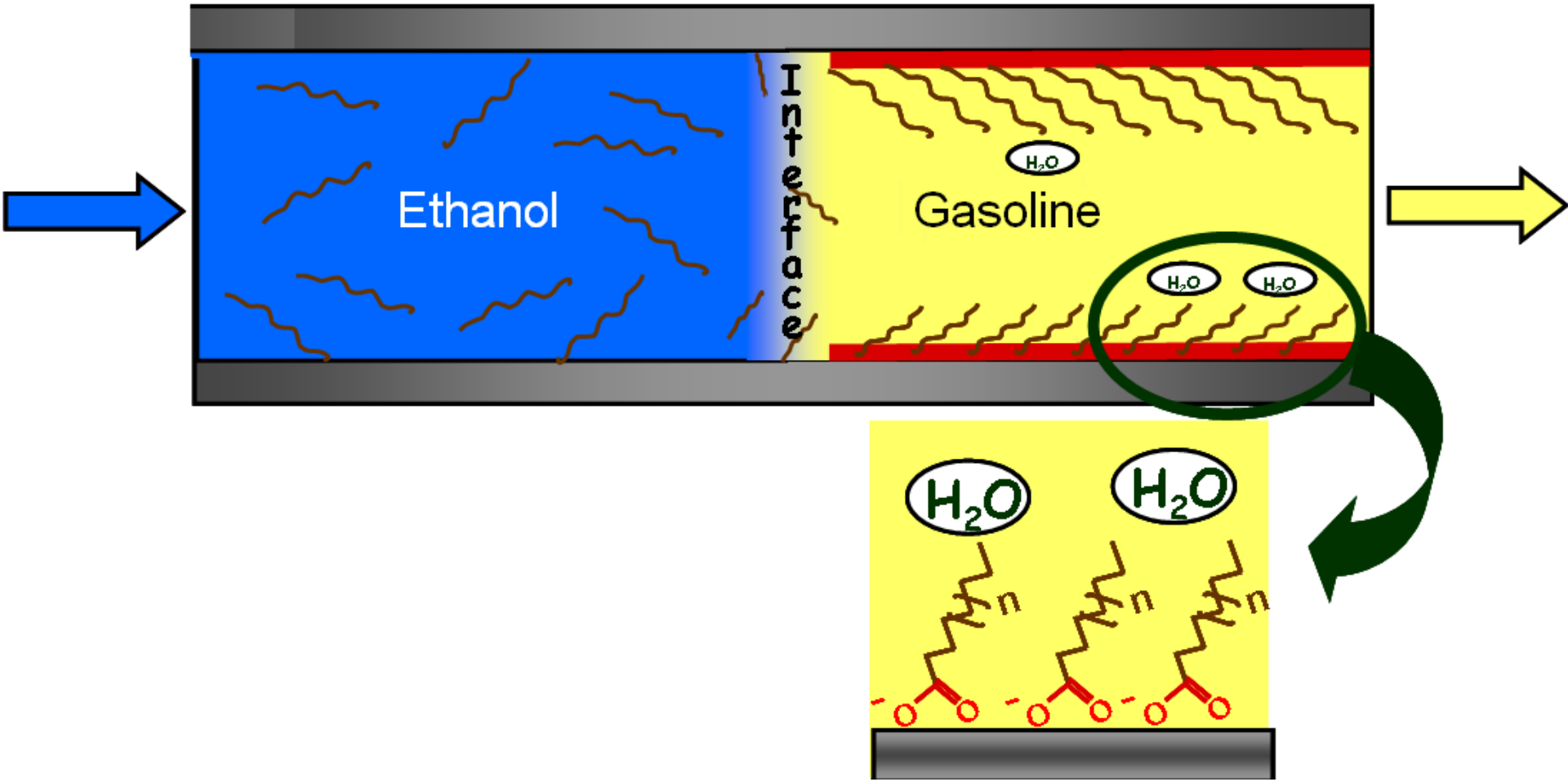
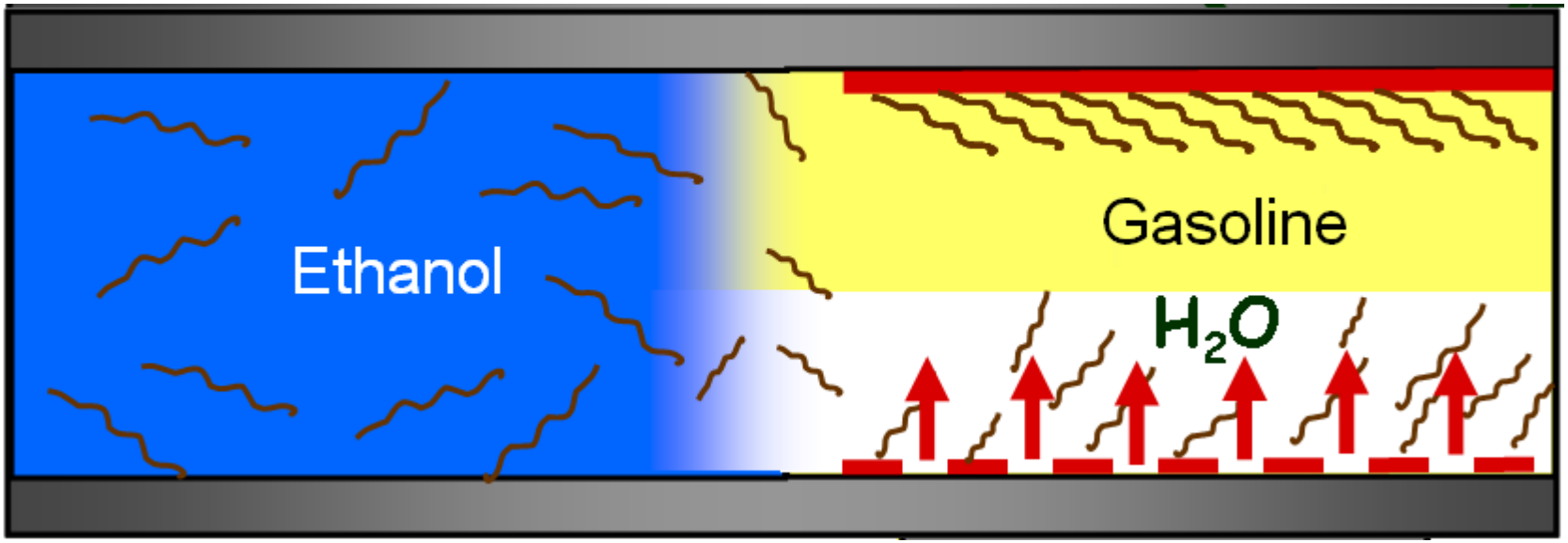
Ethanol Quality:
Poliduct transport

Poliduct during pumping



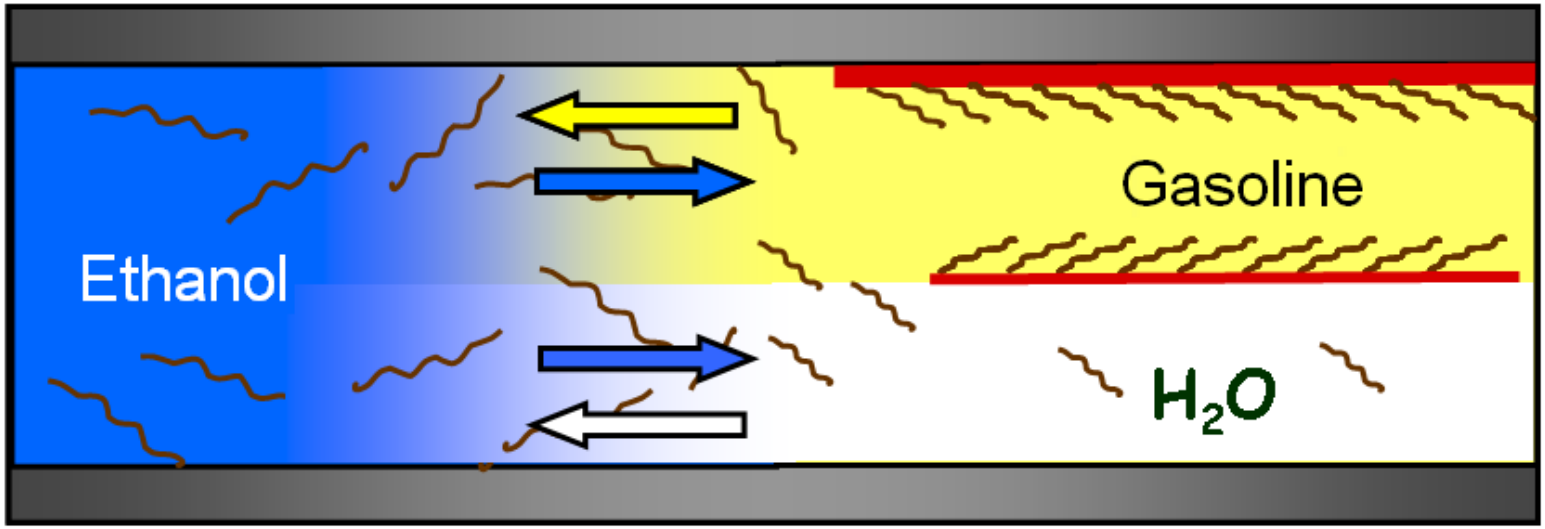
Ethanol Quality:
Poliduct transport

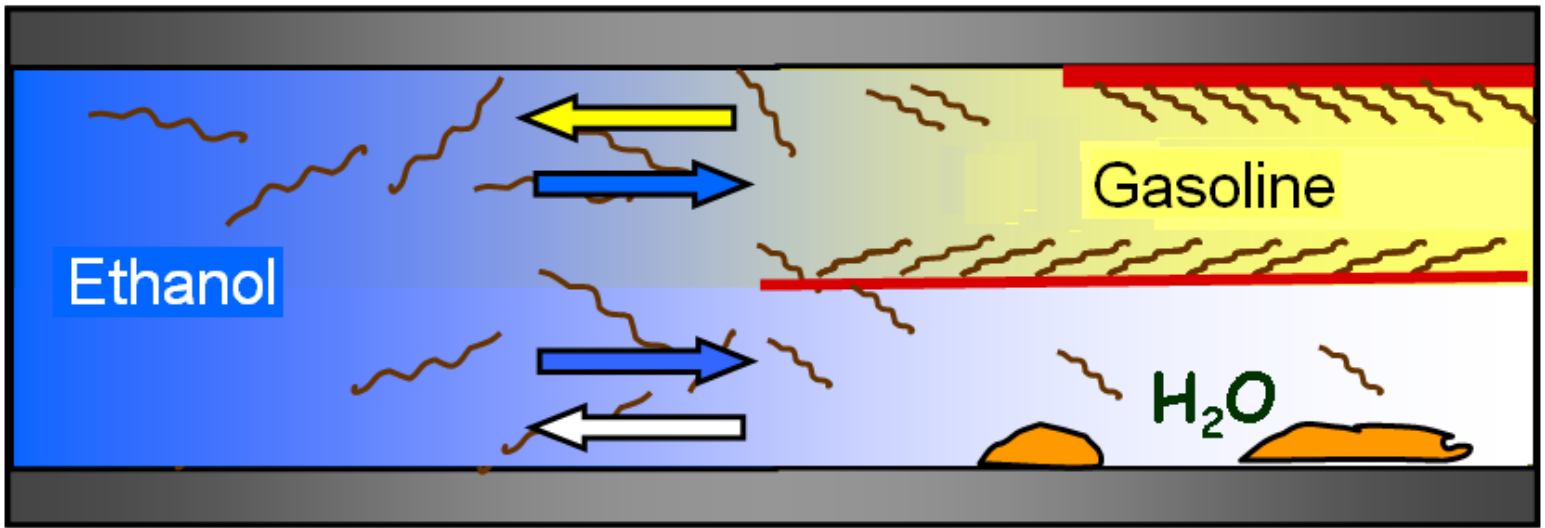
Poliduct: no pumping



Ethanol Quality:
Poliduct transport

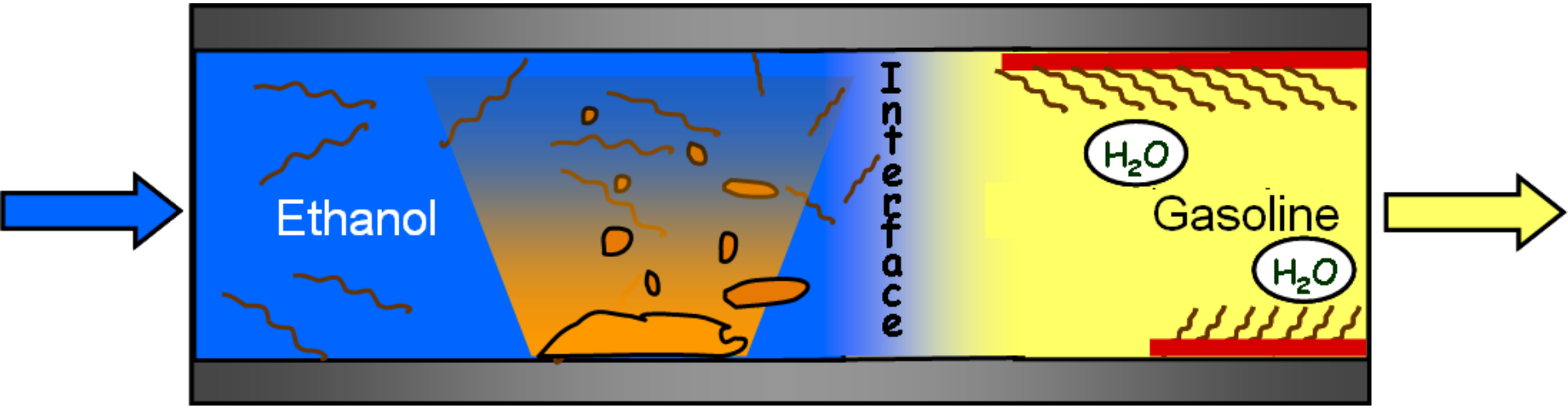
Poliduct: no pumping





Ethanol Quality:
Poliduct transport

Poliduct: pumping restart



Ethanol Quality:
Storage and materials

Materials:

✓ Zinc, lead, aluminum, and brass: not indicated

✓ Stainless steel, carbon steel with or without epoxi, glass (colored): indicated

✓ Carbon steel: applied at gas station and pipelines (Brazil)

Tanks:

✓ To avoid water incorporation - floating ceiling with dome or fixed ceiling with floating membrane

✓Epoxi NOVOLAC: applied for tank painting

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Ethanol Quality:
Corrosion

Ethanol presents low corrosion, but the impurities and water provides corrosion.

For sugar-cane ethanol:

✓*Stress Cracking Corrosion (SCC):* not observed

✓ *Pitting corrosion*: not observed

✓ *Uniform corrosion:* observed in some cases *

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Ethanol Quality:

Inert gas vs. N_2

Inert gas: O_2 amount normally less than 8%vol. and CO_2 around 15%vol.

Ethanol absorbs CO_2: increasing acidity

Nitrogen gas: Nitrogen 99.9%

Recommended for ethanol transport by ship

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Ethanol Quality:
Final remarks

Important issues to be observed:

- ✓ cleanness
- ✓ material type
- ✓ minimize water accumulation
- ✓ nitrogen gas for inerting ships
- ✓ monitor the ethanol quality in the system (color, appearance, etc.)

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