ATC

Fuel Additives
Use & Benefits

Revised and enlarged edition of ATC technical brochure

Agenda

- Presentation of ATC industry body
  - Purpose of ATC
  - Organisation
  - Membership
- Presentation of the Fuel Additives Group (FAG)
  - Membership
  - Typical achievements & activities
- Introduction of Document 113 “Fuel Additives : Use and Benefits”
  - Origin of Document 113
  - Definition of fuel additive, industries & markets covered
  - Market size (EU27)
  - Description of fuel additives use and benefits in various fields

Agenda

- Presentation of ATC industry body
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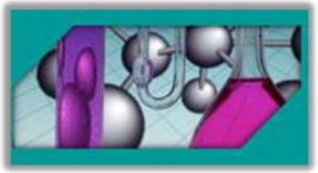
  - Organisation
  - Membership

Presentation of ATC Industry Body

- The Technical Committee of Petroleum Additives Manufacturers in Europe (ATC) was established in 1974 and became an AISBL in Belgium in 2018
- Purpose of ATC

To provide a forum for all Petroleum Additive Companies within Europe to **discuss developments of a Technical or Regulatory nature**



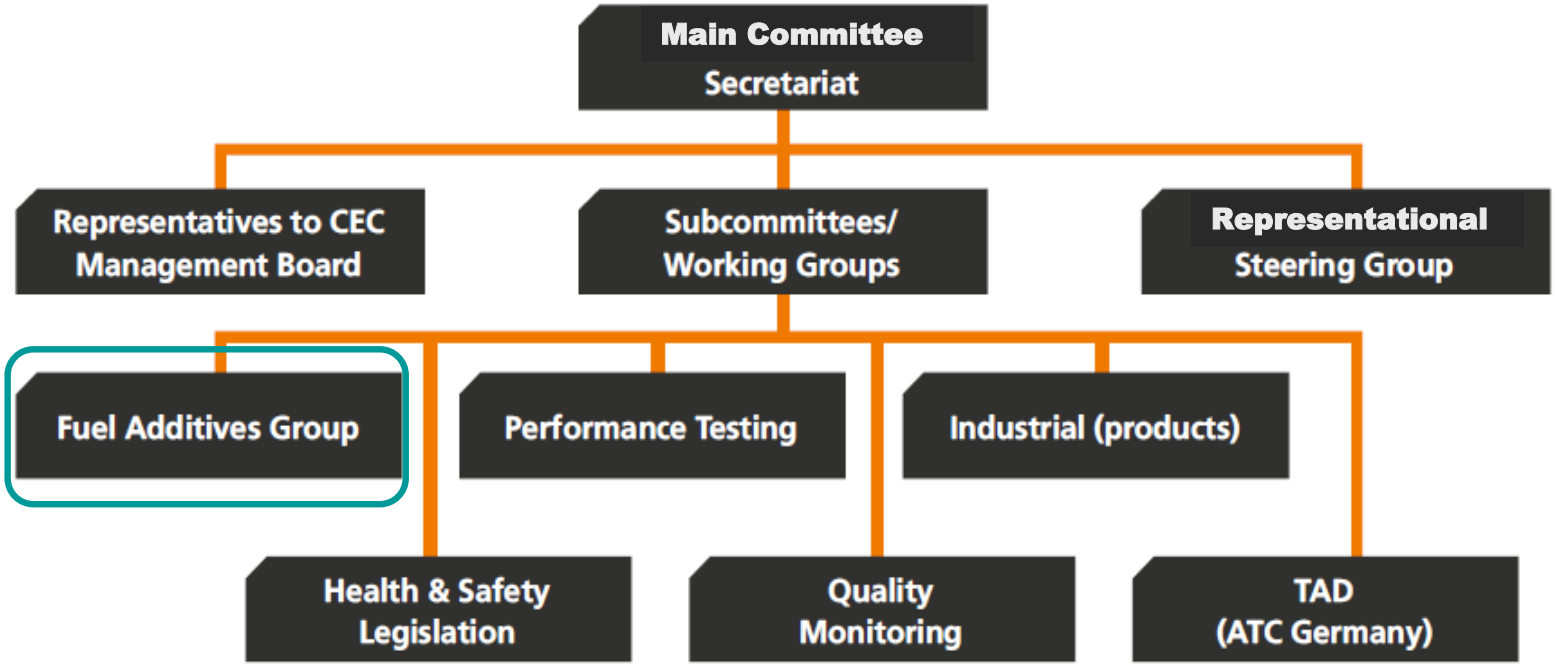
To develop, agree and **publish industry positions** where appropriate

To ensure **communication with other industry** stakeholder groups

To participate **actively in industry test development and maintenance work** to assure **quality and fairness** in product performance testing

Presentation of ATC Industry Body

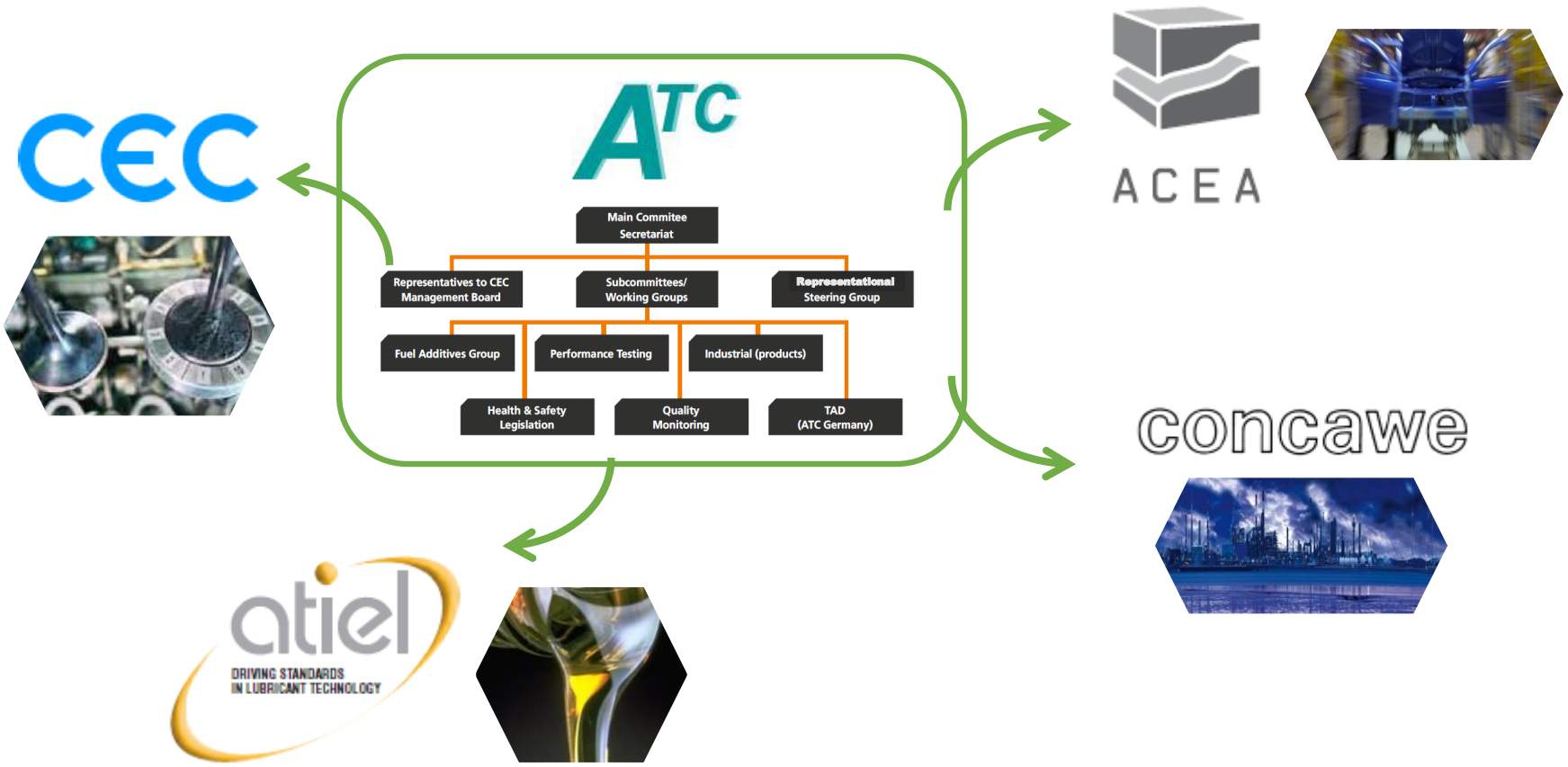
ATC organisation



CEC : Coordination European Council for the Development of Performance Tests for Lubricants and Engine Fuels

Presentation of ATC Industry Body

Fully engaged with associated industry technical bodies



Presentation of ATC Industry Body

- Open to all companies that operate chemical processes in Europe for the manufacture of petroleum additives or manufacture outside of Europe but operate CEC tests within Europe
- Associate membership available for companies active in the distribution or sale of petroleum additives in the Region

Full Members

Afton Chemical – Passion for Solutions

AkzoNobel

BASF – We create chemistry

Chevron Oronite

CRODA

Evonik Industries

Infineum

innospec

LANXESS – Energizing Chemistry

Lubrizol

Total

VeryOne Fuel Improvers

Associate Members

DORF KETAL

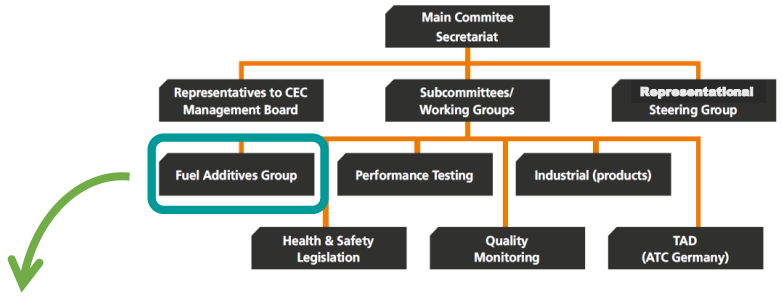
Agenda

- Presentation of the Fuel Additives Group (FAG)
  - Membership
  - Typical achievements & activities

The Fuel Additives Group (FAG)

The working group of ATC dedicated to **Fuel Additives**

Membership



Afton CHEMICAL Passion for Solutions®

AkzoNobel

BASF We create chemistry

VeryOne Leading the way in Cetane Improver

A Division of EURENCO

Infineum

innospec

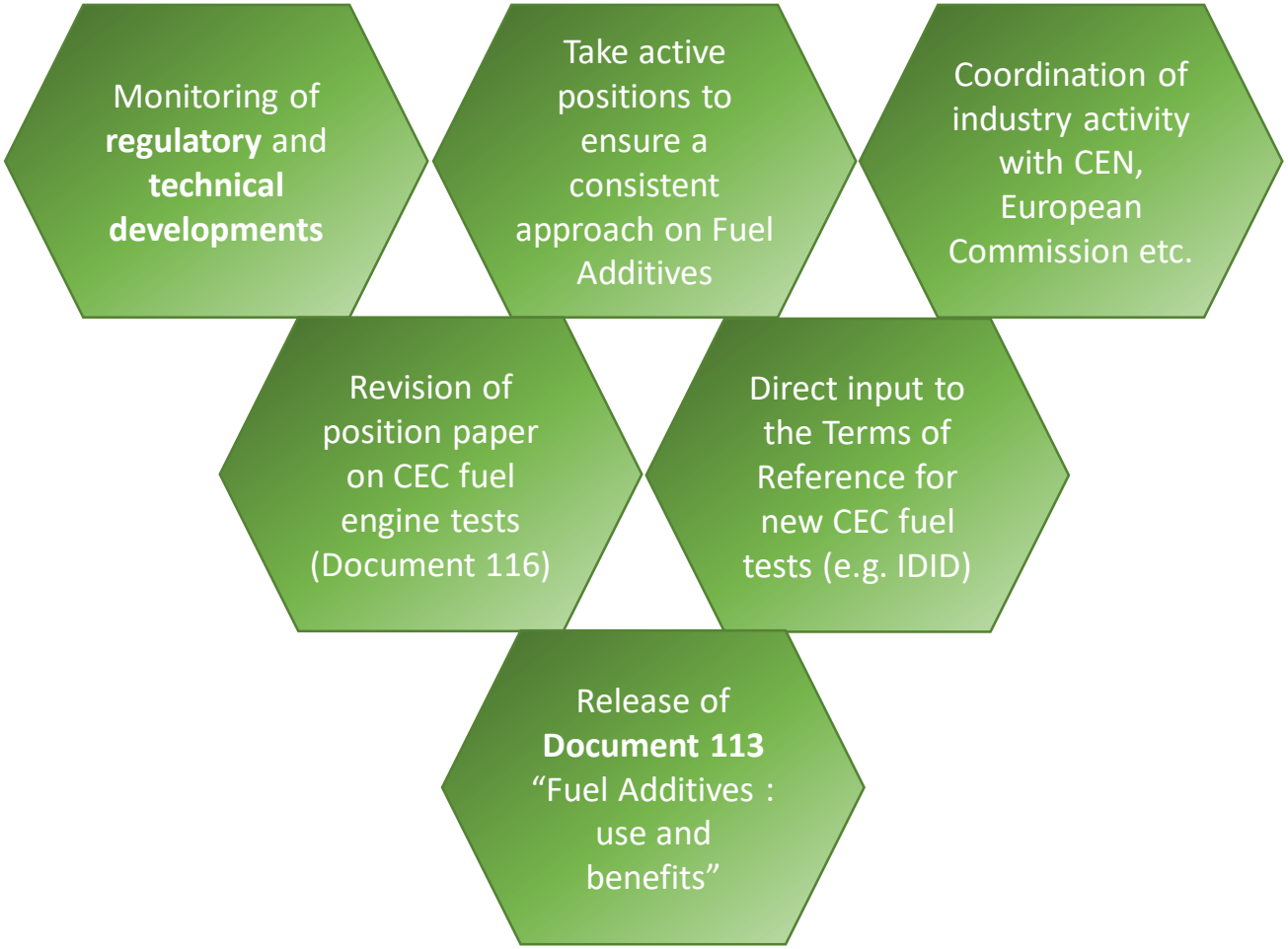
Lubrizol

TOTAL

DORF KETAL™

The Fuel Additives Group (FAG)

FAG typical activities and recent achievements



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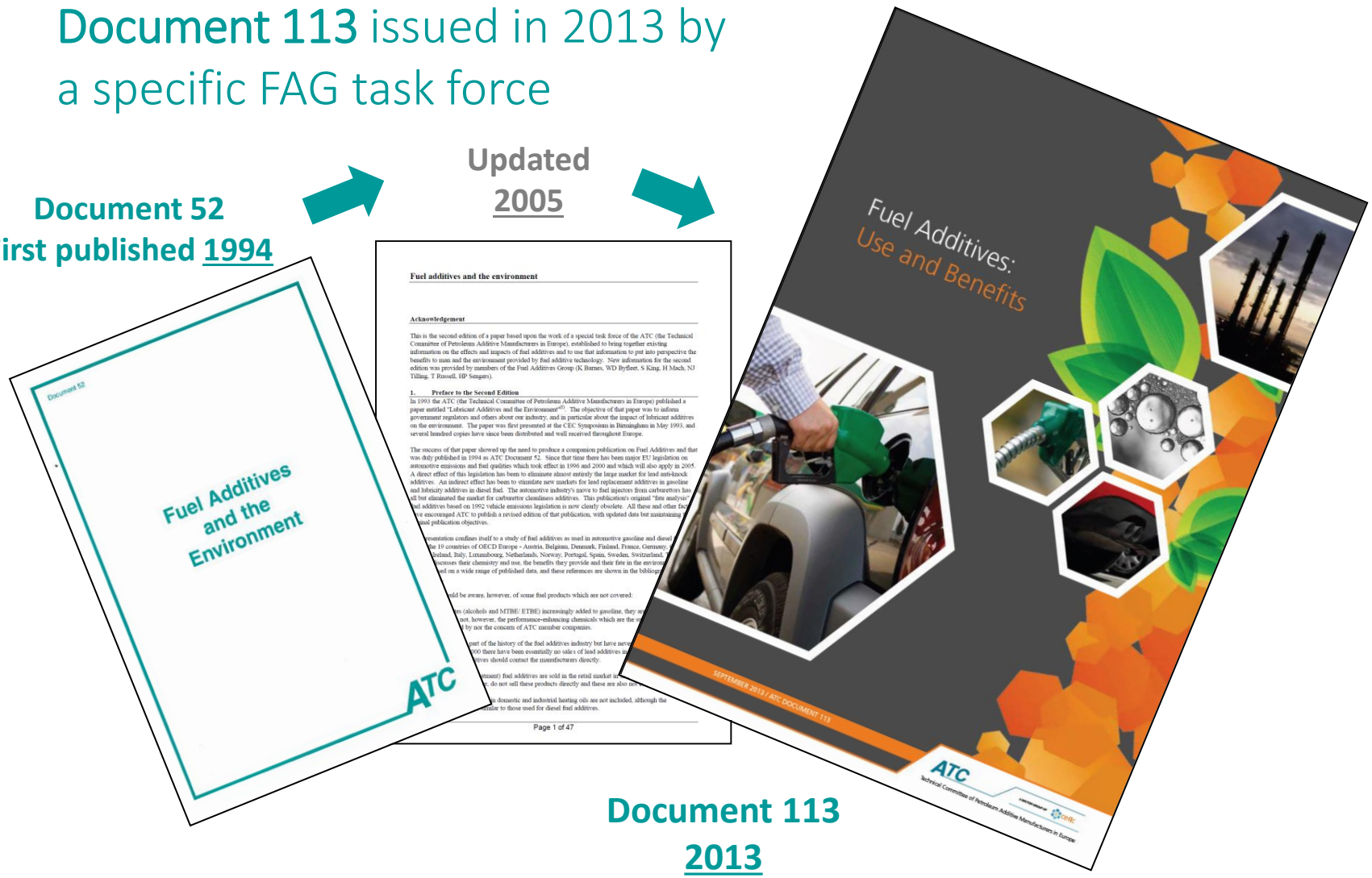
Fuel Additives : Use and Benefits

Document 113 issued in 2013 by
a specific FAG task force

Document 52
First published 1994

Updated
2005



Document 113
2013

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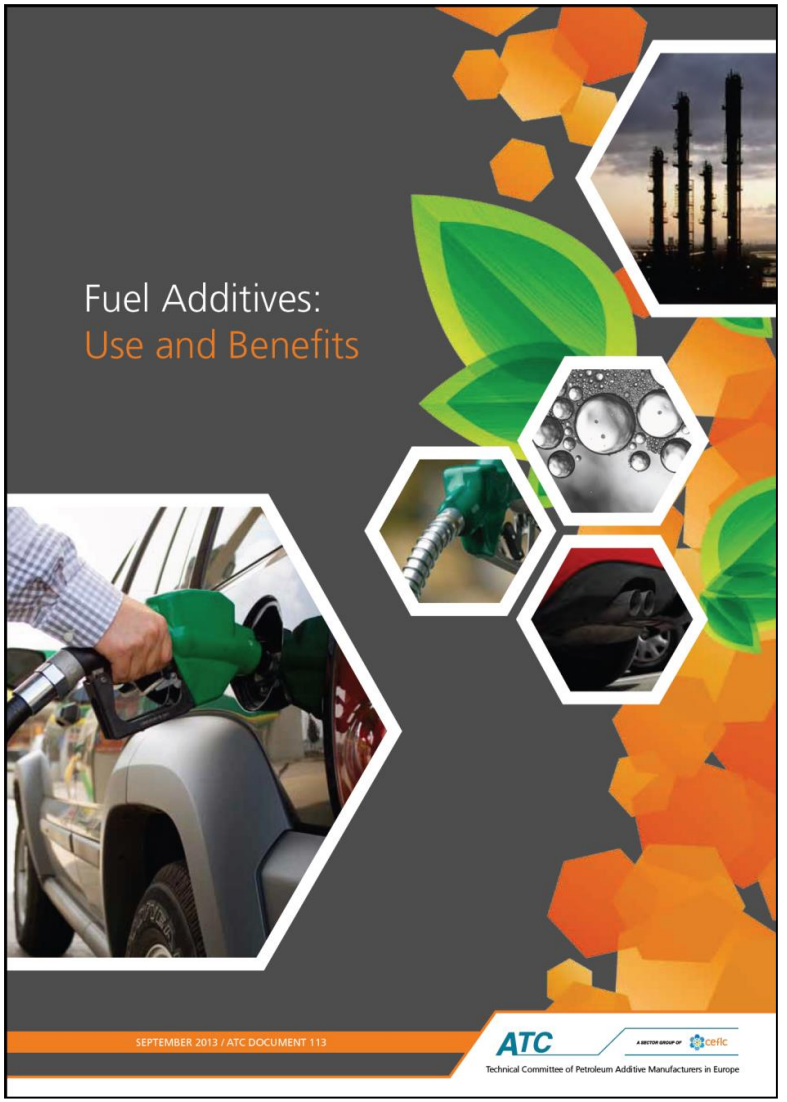

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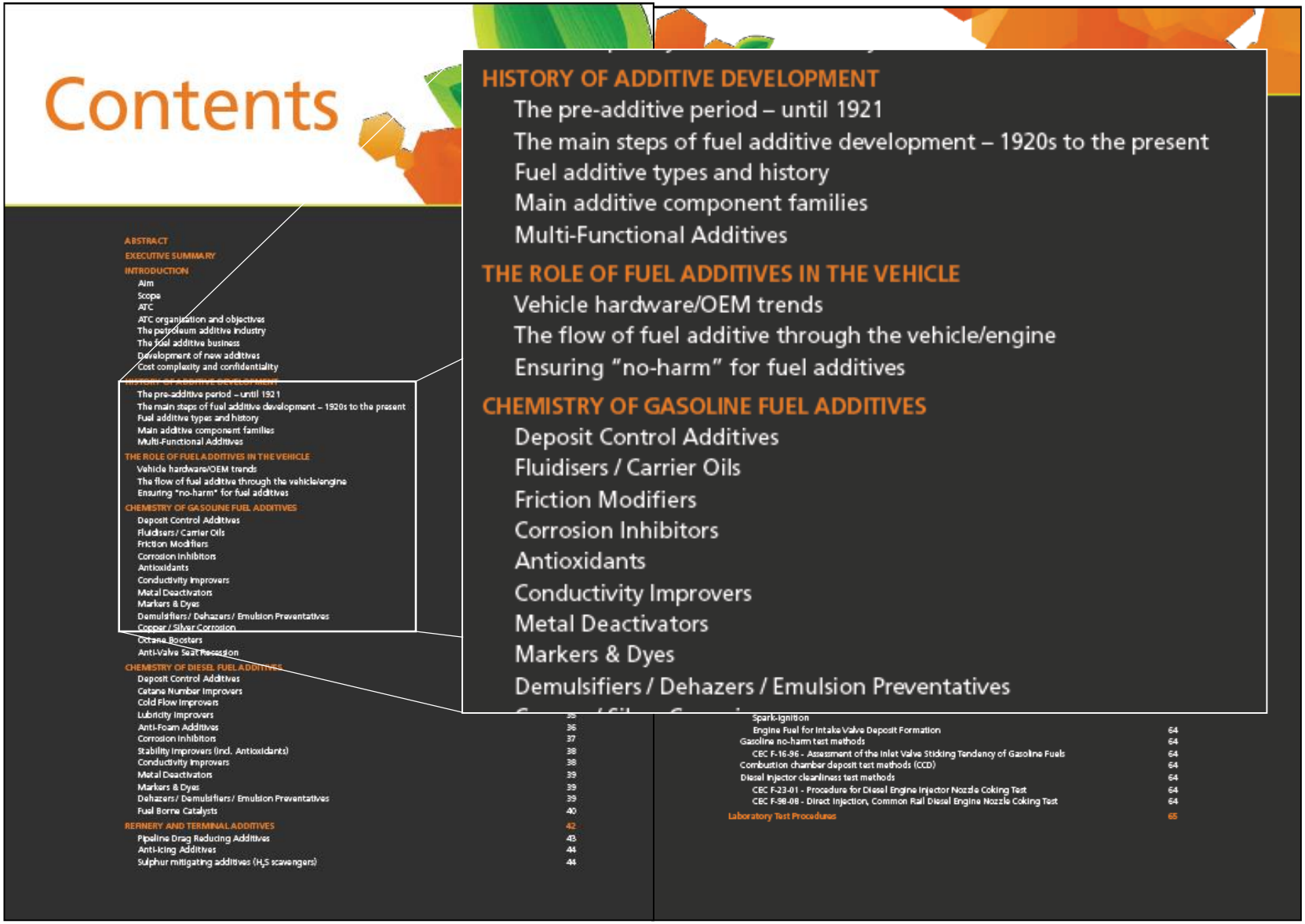
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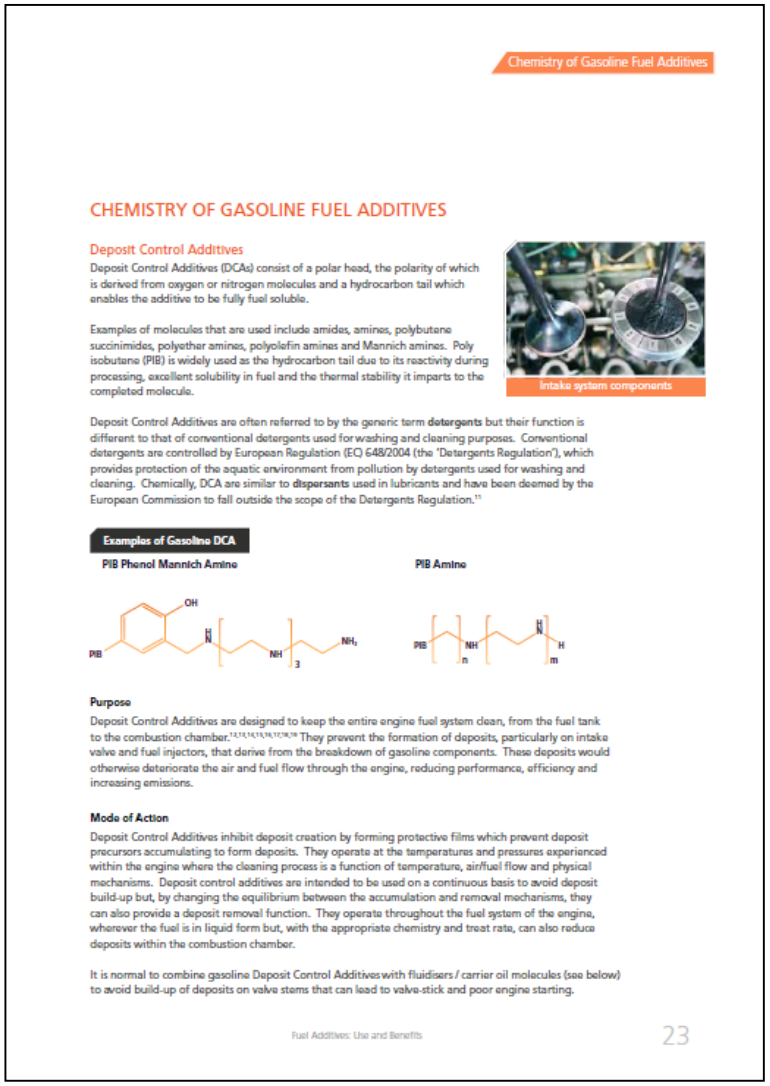
Chemistry of Fuel Additives



CHEMISTRY OF GASOLINE FUEL ADDITIVES

Deposit Control Additives

Deposit Control Additives (DCAs) consist of a polar head, the polarity of which is derived from oxygen or nitrogen molecules and a hydrocarbon tail which enables the additive to be fully fuel soluble.

Examples of molecules that are used include amides, amines, polybutene succinimides, polyether amines, polyolefin amines and Mannich amines. Poly isobutene (PIB) is widely used as the hydrocarbon tail due to its reactivity during processing, excellent solubility in fuel and the thermal stability it imparts to the completed molecule.

Intake system components

Deposit Control Additives are often referred to by the generic term **detergents** but their function is different to that of conventional detergents used for washing and cleaning purposes. Conventional detergents are controlled by European Regulation (EC) 648/2004 (the 'Detergents Regulation'), which provides protection of the aquatic environment from pollution by detergents used for washing and cleaning. Chemically, DCA are similar to **dispersants** used in lubricants and have been deemed by the European Commission to fall outside the scope of the Detergents Regulation.[11]

Examples of Gasoline DCA

PIB Phenol Mannich Amine

PIB Amine

Purpose

Deposit Control Additives are designed to keep the entire engine fuel system clean, from the fuel tank to the combustion chamber.[12,13,14,15,16,17,18,19] They prevent the formation of deposits, particularly on intake valve and fuel injectors, that derive from the breakdown of gasoline components. These deposits would otherwise deteriorate the air and fuel flow through the engine, reducing performance, efficiency and increasing emissions.

Mode of Action

Deposit Control Additives inhibit deposit creation by forming protective films which prevent deposit precursors accumulating to form deposits. They operate at the temperatures and pressures experienced within the engine where the cleaning process is a function of temperature, air/fuel flow and physical mechanisms. Deposit control additives are intended to be used on a continuous basis to avoid deposit build-up but, by changing the equilibrium between the accumulation and removal mechanisms, they can also provide a deposit removal function. They operate throughout the fuel system of the engine, wherever the fuel is in liquid form but, with the appropriate chemistry and treat rate, can also reduce deposits within the combustion chamber.

It is normal to combine gasoline Deposit Control Additives with fluidisers / carrier oil molecules (see below) to avoid build-up of deposits on valve stems that can lead to valve-stick and poor engine starting.

Consistent Approach for each additive type

What they are

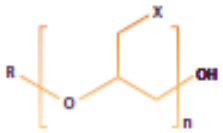
What they do

How they work

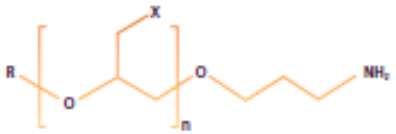
Use of Diagrams and Graphics

Example of Fluidiser

Alkyl polyalkylene glycol ether
(R = C_{12}, X = H, CH_3)



Alkyl polyalkylene glycol etheramine
(R = C_{12}, X = H, CH_3)



Example of Demulsifier

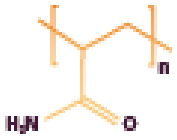
Phenolic resin alkoxylate

A=H or CH_3

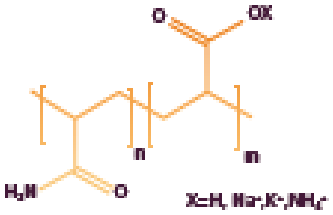
Where possible chemical structures have been included

Example of Pipeline Drag Reducing Additive

Polyacrylamide



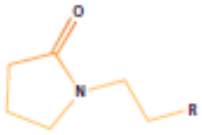
Partially Hydrated Polyacrylamide



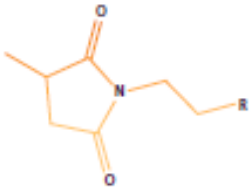
X=H, Na^+,K^+,NH_4^+

Examples Of Asphaltene Dispersant

Alkylpyrrolidone

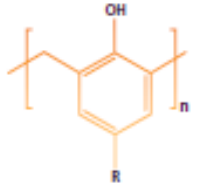


Alkylsuccinimide

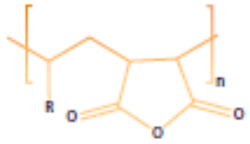


Examples of Ashphaltene Inhibitor

Alkylphenol Formaldehyde Resin (R=C_{3-24} and n=2-12)



Alkene-maleic Anhydride Copolymer



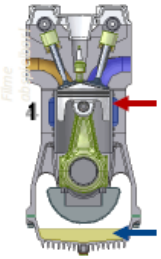
Technical but understandable

Friction Modifiers

Friction modifier (FM) additives are well known and wi
They are generally straight hydrocarbon chains with a
comprise amines, amides and their derivatives or carbo
groups are attracted to metal surfaces such as cylinder
relatively strong bonds, while the long hydrocarbon ta
The nature of the polar head group and the structure
on the contribution to friction reduction.

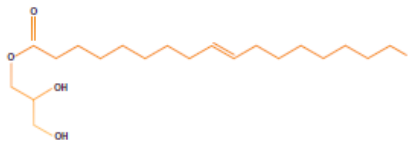
Friction Redution

How does a friction modifier work?



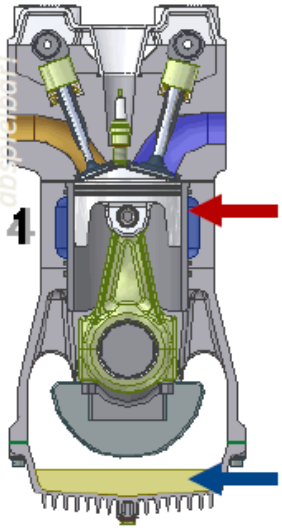
Example of Friction Modifier

Glycerol Mono-Oleate



Friction Redution

How does a friction modifier work?



friction reduction between cylinder wall and piston during motion (instantaneous effect)

potential for further fuel economy improvement

regeneration/accumulation of friction modifier in the engine oil (long term effect)

Informative but easy to read

The Role of Fuel Additives in the Vehicle

Vehicle hardware/OEM trends

The middle decades of the 20th century witnessed a general stagnation in vehicle design, with the main emphasis on reducing initial purchase cost. Since the mid-1970s in the USA and the mid-1980s in Europe however, air quality concerns led to the gradual phasing out of tetra-ethyl lead antiknock additives in gasoline and the reduction of sulphur levels in diesel fuels. Consequent upon these general trends, the demands placed on vehicle manufacturers can be summarised as follows:

- reduced exhaust pollutant levels
- increased specific power output
- increased fuel efficiency
- increased service interval duration
- greater reliability

Some of these demands are conflicting yet, in large measure, have been met. Fuel additives have played a valuable role in assisting Original Equipment Manufacturers (OEMs) to meet these challenging demands, to the extent that OEMs now recognise the value, and recommend the use of, fuel additives in assisting them to meet such requirements. The development of new fuel injection systems, such as high pressure common-rail diesel injection or gasoline direct injection has created further demand for novel products to ensure optimal, long term operation in service.

Ensuring "no-harm" for fuel additives

The fuel additive industry has long recognised the need to ensure that in resolving one issue, the use of a fuel additive does not create another. Products have only received endorsement, or had their use encouraged, if refiners and OEMs have been satisfied that no harmful (in service) effects will result from the use of fuel additives. This is typically accomplished by performing extensive laboratory and/or engine tests and has resulted in the creation of a "no-harm" suite of tests, performed to demonstrate the absence of adverse effects of fuel additive use.

Awareness of the need for such tests comes from effective dialogue and collaboration between oil refiners and retailers, the fuel additive industry and vehicle and engine manufacturers. When problems are noted in service, test methods are developed to simulate the problem, enabling fuel additives to be tested to an agreed performance level before the product is released for sale. Examples of this process below demonstrate how fuel additives and test methods have evolved to overcome issues of unwanted adverse side effects in the past.

Intake valve sticking

Some gasoline deposit control additives were found to permit the formation, at the intake valve stem/guide interface, of a film whose viscosity increased very significantly at low ambient temperatures. Under these conditions, on cold cranking immediately prior to start-up, one or more intake valves could stay open, with the compressed valve spring unable to close the valve in time to allow cylinder pressures to rise satisfactorily, with engine cold starting and operation potentially severely compromised as a result.[9] The additive industry responded by developing a specific test procedure using an engine noted to be particularly (and severely) affected by the problem. This test procedure is now a standard no-harm test for multifunctional gasoline additive packages.

Lubricating oil interaction

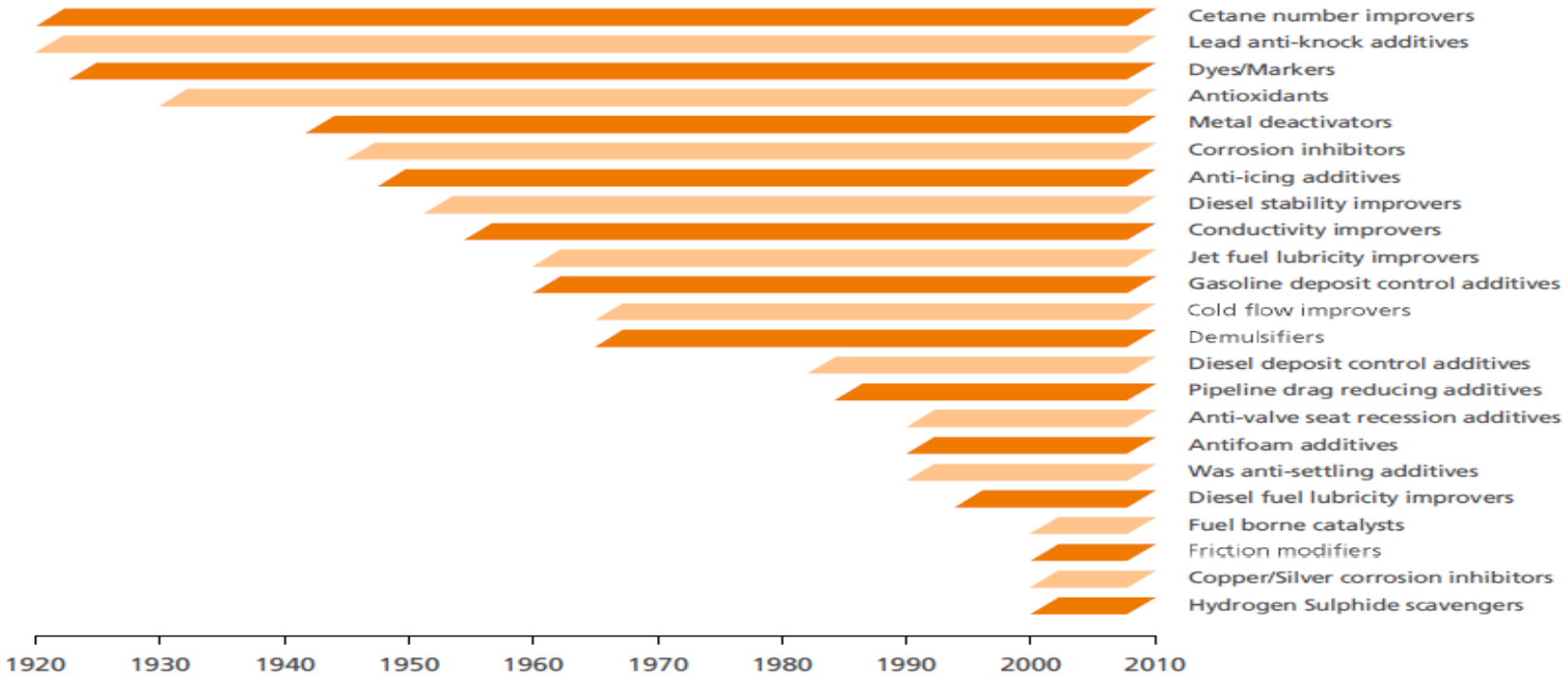
Some lubricity additives used in low sulphur diesel fuels were found to react adversely to contact with crankcase lubricating oil.[10] The potential for contact between crankcase lubricating oil and diesel fuel occurs in some in-line injector pumps used on many heavy duty diesel engines. Where problems occurred, deposits in the pump plunger region could seriously impair pump operation, with resulting loss of engine power output or possibly complete shutdown. The fuel and additive industry rose to this challenge by developing laboratory interaction tests involving both new, and used, crankcase lubricating oil and candidate lubricity additive chemistries, to ensure that no deposits would occur in service. Such tests have now become standard no-harm tests for diesel fuel packages containing lubricity additive.

Fuel Additives : Use and Benefits

- Definition of a fuel additive
  - " A chemical substance or preparation, added to fuel, in concentrations typically less than 1%, to impart or enhance desirable properties or to suppress undesirable properties."
- Fuel additives address the oil / energy / transportation industries in many ways
  - fuel in motor vehicles, aircrafts and marine vessels
  - fuel / oil in power stations and domestic heating
  - refinery process streams

Fuel Additives : Use and Benefits

- Fuel additives type and history
  - in the early stages, additives focussed on improvement of combustion properties of poorly refined cuts (octane, cetane)
  - modern additives cover a broad spectrum of uses, including improved safety, operation and process, and end-use performance of fuels



Fuel Additives : Use and Benefits

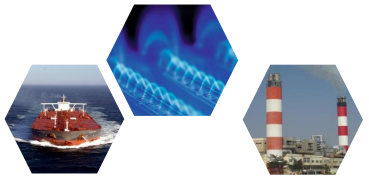
- A comprehensive survey of market data collected from FAG members though CEFIC's statistical service (to ensure anonymity of the data), has estimated that

  - The EU27 market for fuel additives is over 200,000 tons per annum and has a value of over €500 million
  - Over 95% of road retail fuels is treated with performance additives
  - All European refineries use additives in some capacity

[2009-2011 figures]

Fuel Additives : Use and Benefits

Typical components and uses



	Refining / terminal	Transportation	Heating / Power gen.
Antioxidants	■	■	■
Stability improvers	■		■
Deposit Control	■	■	
Octane / cetane imp.	■	■	
Combustion imp.		■	■
Metal deactivators	■	■	■
Drag reducers	■		
Dyes	■	■	■
Lubricity improvers	■	■	
Friction modifiers		■	
Cold Flow improvers	■	■	■
Antifoam	■	■	
Corrosion inhibitors	■	■	■
Antistatic	■	■	
Dehazers	■	■	■
Reodorant		■	■

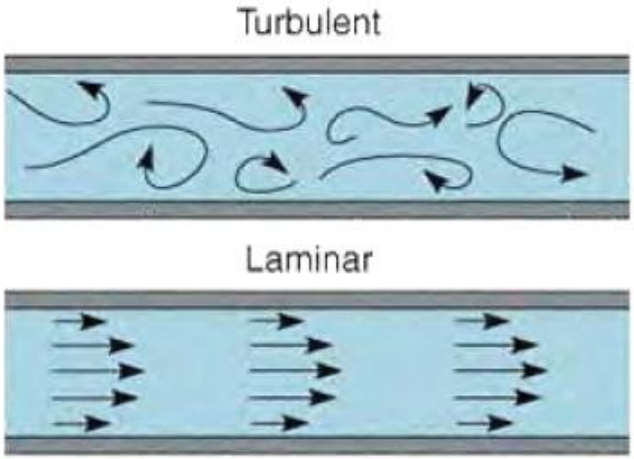
Fuel Additives : Use and Benefits

Refining and Terminal additives

The use of additives provides **safer operations**, **improved processes** and **blending flexibility / optimisation**

Technical Problem

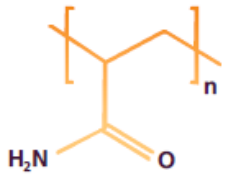
Pipeline pressure drop due to turbulent flow → lower throughput, higher pumping energy required



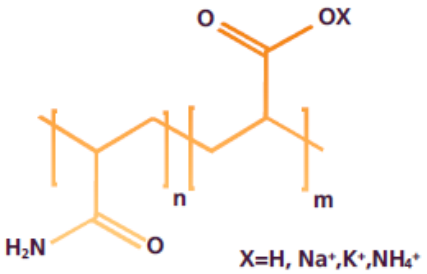
Additive / mode of action / benefit

DRAG REDUCERS / reduction of transverse flow / maintains throughput and pumping energy

Polyacrylamide



Partially Hydrated Polyacrylamide



Fuel Additives : Use and Benefits

Refining and Terminal additives

The use of additives provides **safer operations**, **improved processes** and **blending flexibility / optimisation**

Technical Problem

Paraffin crystallisation

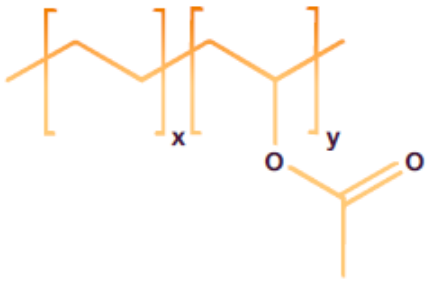
→ diesel fuel filter clogging

→ requires high amounts of specific cuts (e.g. kerosene) in the blending pool

Additive / mode of action / benefit

COLD FLOW IMPROVERS / delays crystal growth / lowers engine cold start temperatures

EVA: Ethylene Vinyl Acetate



Fuel Additives : Use and Benefits

Refining and Terminal additives

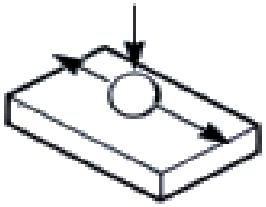
The use of additives provides **safer operations**, **improved processes** and **blending flexibility / optimisation**

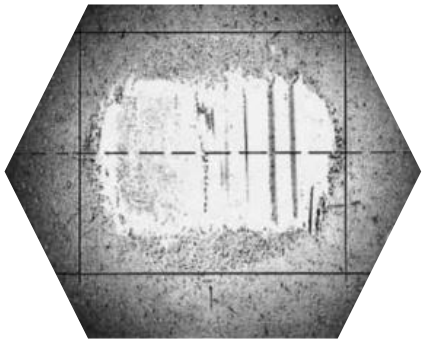
Technical Problem

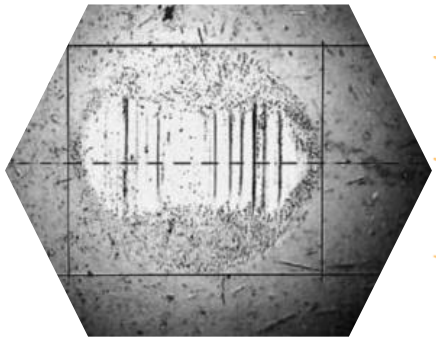
Desulphurisation reduces fuel polarity
→ vehicle fuel pump failure

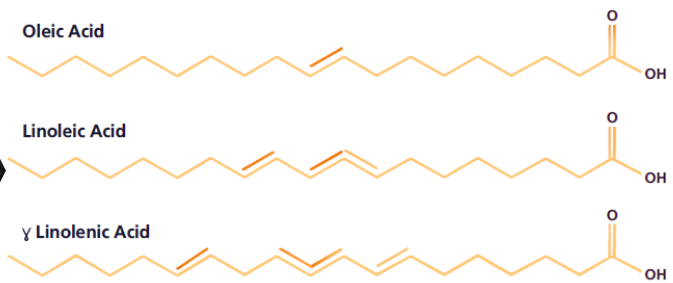
Additive / mode of action / benefit

LUBRICITY IMPROVERS / protective film / high lubricity ULSD fuels









Fuel Additives : Use and Benefits

Refining and Terminal additives

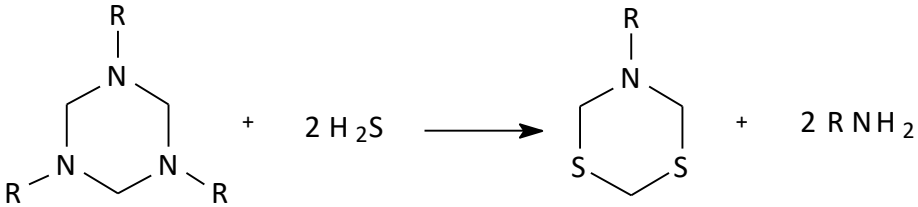
The use of additives provides **safer operations**, **improved processes** and **blending flexibility / optimisation**

Technical Problem

Entrainment of **H_2S** in hydrocarbons
→ potential personnel exposure

Additive / mode of action / benefit

H_2S SCAVENGERS / chemical reaction with H_2S into low hazard stable product / no H_2S release



Fuel Additives : Use and Benefits

Automotive fuel additives

The use of additives maintains **original engine cleanliness** , improves **efficiency** and **protects engine parts**

Technical Problem

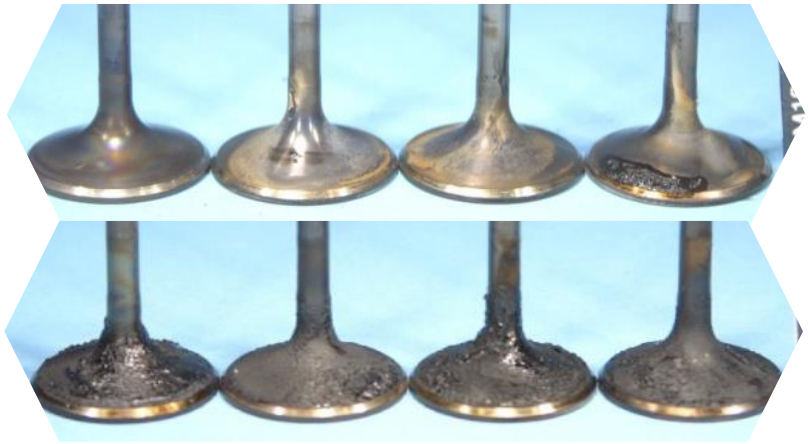
Gasoline inlet valve dirty-up

→ modified air/fuel ratio

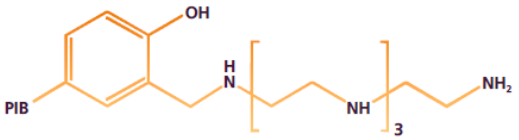
→ lowered efficiency (consumption, emissions)

Additive / mode of action / benefit

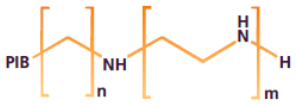
DEPOSIT CONTROL ADDITIVES / protective film / maintains original engine performances and emission levels



PIB Phenol Mannich Amine



PIB Amine



Fuel Additives : Use and Benefits

Automotive fuel additives

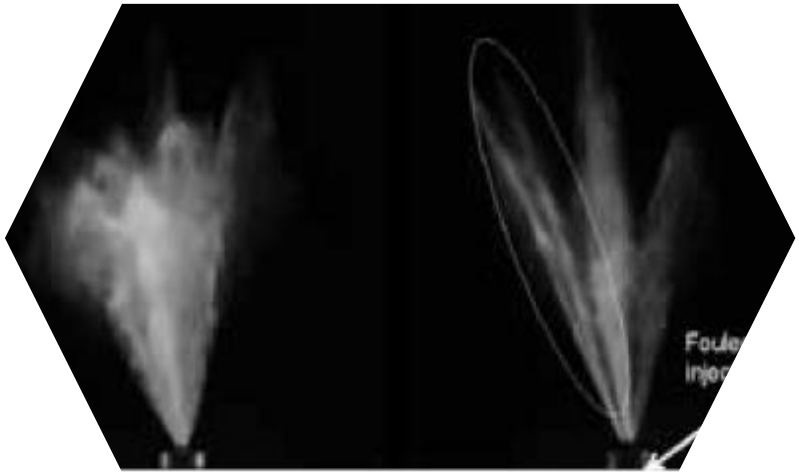
The use of additives maintains **original engine cleanliness** , improves **efficiency** and **protects engine parts**

Technical Problem

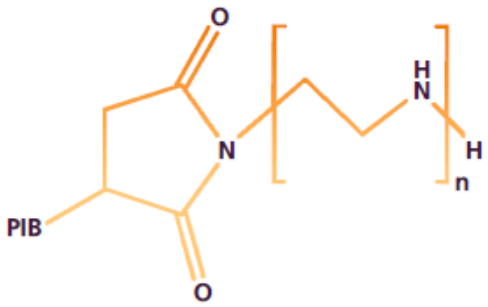
Diesel Injector fouling
→ **modified spray /combustion**
→ lowered efficiency
(consumption, emissions)

Additive / mode of action / benefit

DEPOSIT CONTROL ADDITIVES / protective film / maintains original engine performances and emission levels



PIBSI: Polyisobutylene Succinimide



Fuel Additives : Use and Benefits

Automotive fuel additives

The use of additives maintains **original engine cleanliness** , improves **efficiency** and **protects engine parts**

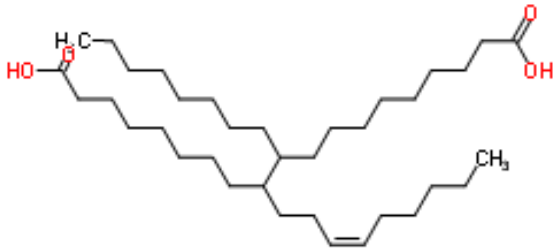
Technical Problem

Steel corrosion, rust formation
→ reduces parts lifetime
→ filters blocking

Additive / mode of action / benefit

CORROSION INHIBITORS / polar molecules forming protective film / reliable operation, long life

Oleic acid dimers



Fuel Additives : Use and Benefits

Automotive fuel additives

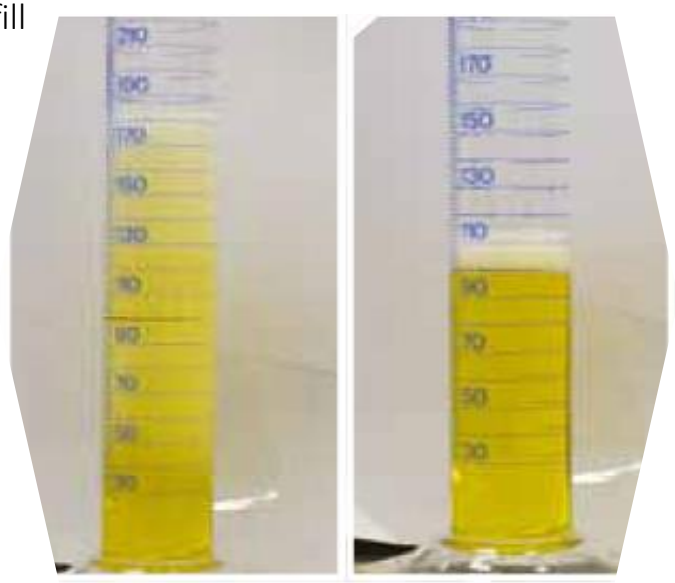
The use of additives enables **safer**, **easier** and **cleaner** operation

Technical Problem

Diesel foaming

→ filling overflow

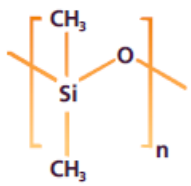
→ incomplete tank fill



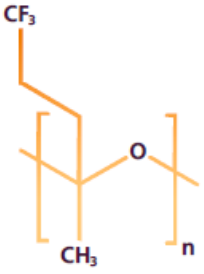
Additive / mode of action / benefit

ANTIFOAMS / reduce surface tension / lower foam volume and faster defoaming time

Polydimethylsiloxane



Modified Polydimethylsiloxane



Fuel Additives : Use and Benefits

Automotive fuel additives

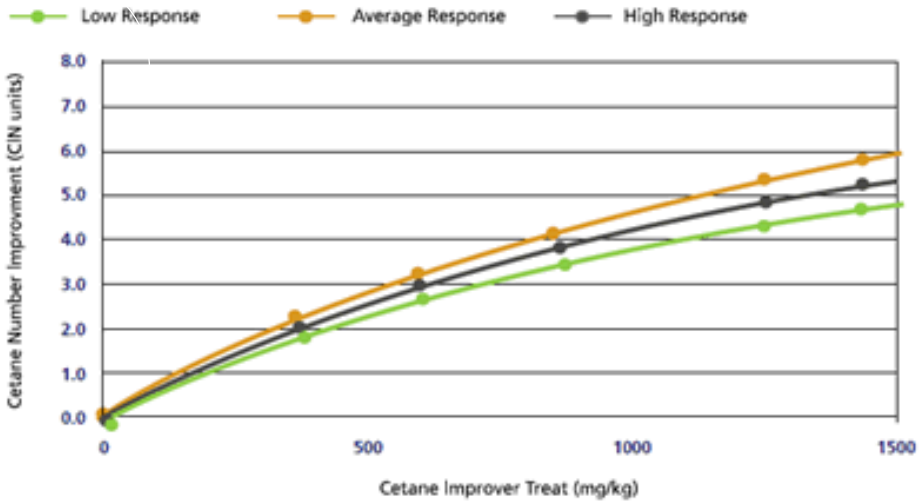
The use of additives maintains **original engine cleanliness** , improves **efficiency** and **protects engine parts**

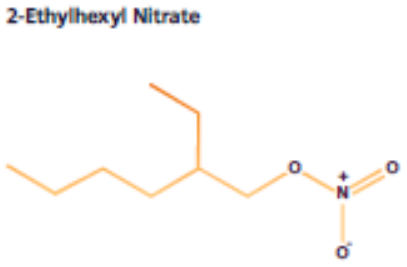
Technical Problem

Poor diesel combustion behaviour

Additive / mode of action / benefit

CETANE IMPROVERS / lowers ignition delay / more efficient combustion, lower noise





Fuel Additives : Use and Benefits

Automotive fuel additives

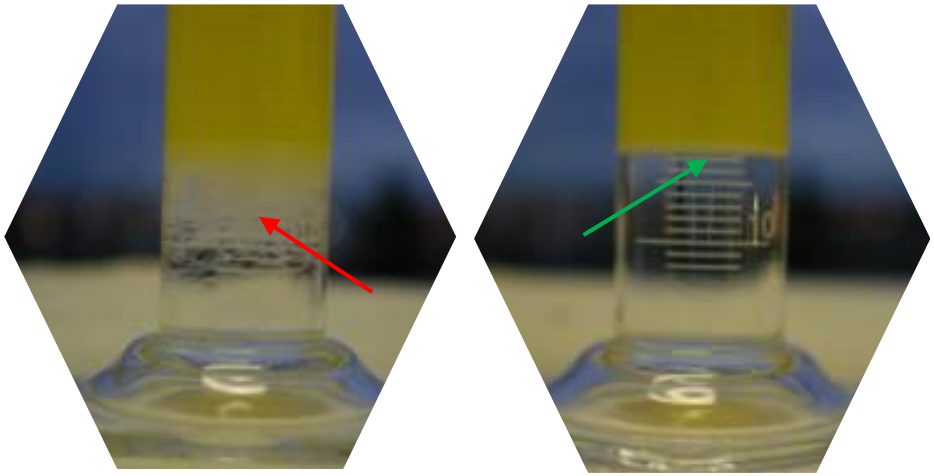
The use of additives maintains **original engine cleanliness**, improves **efficiency** and **protects engine parts**

Technical Problem

Water ingress in hydrocarbons
→ formation of emulsion
→ higher corrosion, fuel blocking, microbial growth

Additive / mode of action / benefit

DEHAZERS / break fuel-water interface / water separation



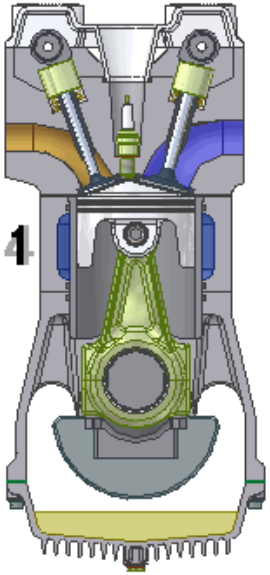
Fuel Additives : Use and Benefits

Automotive fuel additives

The use of additives maintains **original engine cleanliness**, improves **efficiency** and protects **engine parts**

Technical Problem

Friction at the piston ring-cylinder wall interface
→ lowered efficiency



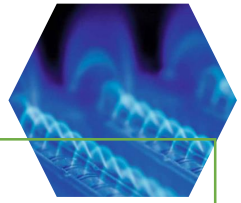
Additive / mode of action / benefit

FRICTION MODIFIERS / Surface coating to form a lubricating film / Enhanced efficiency (consumption, emissions, acceleration)

Glycerol Mono-Oleate

Fuel Additives : Use and Benefits

Heating oil / marine / residual additives



The use of additives enhances **thermal stability**, improves **combustion properties**, disperses **impurities and** eases **product handling**

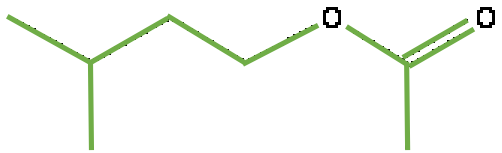
Technical Problem

Delivery and storing of domestic heating oil may lead to odour nuisance

→ Consumer complaints

Additive / mode of action / benefit

REODORANT / masks characteristic fuel smell / Easier product handling



Fuel Additives : Use and Benefits

- Conclusions

  - Fuel additives offer a wide range of technical solutions to improve operation and performance in the oil / energy / transportation industries
  - Fuel additives business (manufacture, R&D, use) represents a significant part of the European chemical industry
  - ATC plays a **key role in the industry** by providing forum for all Petroleum Additives Companies within Europe to discuss developments of a technical or regulatory issue
  - ATC will continue to participate actively in **industry test development** and maintenance work to assure quality and fairness in product performance testing
  - ATC's new **Document 113** outlines the benefits of fuel additives

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