ROAD TRANSPORT FUELS - QUALITY AND AVAILIBILITY AHEAD

John Savage

CONSULTANT

UK

Presented to the

Institute of Road Transport Engineers of New Zealand

FOURTH INTERNATIONAL HEAVY VEHICLE SEMINAR

AUCKLAND

3 - 5 March 1992

The Institute of Road Transport Engineers of New Zealand

FOURTH INTERNATIONAL HEAVY VEHICLE SEMINAR

AUCKLAND 3 - 5 MARCH 1992

Road Transport Fuels - Quality & Availability Ahead

by

J D Savage, C Eng, FIMechE, HonFIRTE, MSAE

The Institute of Road Transport Engineers of New Zealand

FOURTH INTERNATIONAL HEAVY VEHICLE SEMINAR

AUCKLAND 3 - 5 MARCH 1992

Road Transport Fuels - Quality and Availability Ahead

J D Savage, C Eng, FIMechE, Hon FIRTE, MSAE

INTRODUCTION

Since World War II the predominant fuel in world-wide road transport has been diesel fuel. Despite problems in meeting quality and volume demands it will continue to dominate for another 25 or 50 years, perhaps even longer. During that time other fuels will play an increasing support role but will not oust diesel from the over-all lead. Only in limited localities where "cleaner" alternative fuels make economic sense will they have any great impact.

CONTENTS

UBIQUITOUS DIESEL

The wide-spread use of the exceptionally reliable diesel is encouraging designers in Europe and North America to meet the stringent environmental demands being imposed upon it, rather than turn to alternatives. Remarkable sophistication is being introduced to achieve this. At the same time, the diesel's vital role in basic form as the "work-horse" in the survival race of developing countries will not diminish.

old "workhorse"

new sophistication

This will call for a continuing generous supply of fuel to suit existing and current-production engines while a more exacting fuel is made available for the environmentally-friendly engines of the future. The transition from conventional engines to new-era designs will be lengthy. The transition will be dictated by the diesel's long service-life and the economic need to exploit it by coaxing old engines to work - somewhere or other - until they "drop".

two fuels over transition period

Dr Carl Hahn, Chairman of Volkswagen, considers that less-prosperous markets should not be supplied with cast-off "dirty" engines. (Ref. 1) But, economics will rule. "Clean" vehicles will not be on struggling countries' shopping lists for some time. Meanwhile, the smoky, smelly, noisy diesel will continue to serve them well.

This will lead to considerable differences in quality around the world just when there are increasing demands for unified specifications across national boundaries, eg, in Europe. (Table 1)

unified specifications

DIESEL FUEL - Past & Future

Once it was a simple distillate from crude oil with nothing added and nothing taken away. Such fuel is produced today, but in small volume, and it is increasingly enhanced by the addition of components processed from heavy fuel oil. Sulphur and wax are now greatly reduced and soon will be "taken away". Chemicals will be routinely added to improve ignition, flow and lubricity. Detergent and dispersant materials will be added too. In this way the exacting demands of the environmentally-friendly diesel can be met. The demand for volume will be satisfied. (Ref.2)

from simple distillate to complex "cocktail"

Quality

There have been only two widespread quality problems in the past: one associated with tropical areas, the other with low temperatures.

Tropical.

The problem, bacterial growth at the interface between the fuel and the tank water bottoms, is due to poor storage management. It should be a thing of the past as the benefits of good "housekeeping" are now well known and understood. Biocides are readily available too. In future, the processing and chemical treatment of premium fuels, such as the reduction of sulphur, will make it less vulnerable to bacteria.

need for good "housekeeping"

use of biocides

....

Low temperature.

The diesel's reputation for poor startability at low temperature is justified. It is due to the low temperature of the inlet air and a loss of heat, during the compression stroke, to the adjacent cold metal of the cylinders. Superior ignition-quality would help starting and reduce combustion noise, but this property is often deficient in fuels for cold countries because essential de-waxing, (in the interest of cold flow) removes the paraffinic molecules that impart good ignition quality. Equally, fuels that are naturally low in paraffinic (waxy) molecules tend to have poor ignition quality. Consequently, diesel engines are inherently more difficult to start at low temperatures, unless starting aids are fitted to add heat - and this practice is likely to increase.

inherently poor startability

This inherent weakness may be alleviated in future by the increasing use of ignition-improving chemicals. These are added at the refinery to offset the loss of ignition quality as a result of de-waxing or the use of inferior components. Flow-improving chemicals will continue to be used but they are rarely good enough on their own so de-waxing or wax conversion will be a feature of the future. Eventually, conversion of paraffinic molecules to less waxy ones may be arranged to enhance ignition quality.

ignition improvers

At high and low ambient temperatures water in fuel tanks is still a problem. Fleet operators the world over could do much to reduce the incidence of water in fuel by adopting the most simple of routine practices. (Ref.3)

water!

New Quality requirements

To help meet limits being imposed on noise and exhaust emissions, good ignition quality and flow will be as important as ever. In addition, greater care will be taken to control sulphur, viscosity, volatility and lubricity at the refinery. Freedom from contamination by bacteria, particulates and water will be an even greater responsibility of the user.

tighter quality Specs.

The specification of diesel fuel properties to much tighter limits than in the past will enable electronically-managed fuel injection systems to provide the precise control of fuel delivery dictated by environmental regulations of the future. Despite the demanding regulations, the diesel will be developed to meet them because there is no alternative.

no alternative

The required performance will be achieved via electronics, combustion efficiency, catalytic convertors and fuel quality. Within existing technology, there is no other way.

no other way

The use of a wider range of raw materials and components will make it possible to produce tailor-made fuels in sufficient quantity to meet demand. This would not have been possible if only "pure" straight-run distillate was available. (Appendix I)

more components

....

The environmentally friendly diesel.

Although fuel quality alone will not make the diesel acceptable, it will make a valuable contribution. A rearguard action will, as ever, be fought by the oil industry in an attempt to resist being pushed too far, too fast, over aspects like sulphur reduction. But, while the rearguard action is being fought, the "backroom boys" will be developing processes and components to enable the product to survive as the revenue-earning merchandise that it is now. After initial resistance individual companies will find, as with unleaded gasoline, that it is possible to meet and even exceed requirements. Then, in no time at all, they will claim unique properties in promotions that seek - in the jargon of the industry - to establish product differentiation. (In other words, claims will be made for better properties with the brand in question.)

branded products lead

The next step is for features of branded fuels to be adopted in national and international specifications. It takes a long time to complete this stage because companies with inferior products get "protection" in inter-industry bodies. As a result, official specifications represent lowest common denominators not the best available practice.

national Specs. follow slowly

Eventually, by dint of internal developments, licensing agreements, product exchanges, bulk purchases or mergers and take-overs, the whole industry is able to meet the new Specs. Reference Fuels used in standard tests by the engine industry are revised to recognise the latest technology and a new level of performance becomes the norm for five, ten or twenty years. The process does not then "start all over again" because it is continuous with overlapping developments on different characteristics spreading out from the main centres of excellence.

These centres are mainly Europe and North America. Exceptional developments in the production of diesel fuel from coal and unattractive crudes have been achieved in South Africa and much of that technology may one day be used more widely. (Ref.4). Japan has led some remarkable advances in engine design but has not yet influenced the world at large in respect to innovatory fuel development. But a dependence on imported crude oil and a bent for lateral thinking may soon lead to novel fuels emerging from Japan.

new technology

GASOLINE

The fuel of second-most importance to the fleet engineer is gasoline - and it will continue to be as important to him for decades more because of his responsibilities for light vans and fleet cars.

Gasoline development is being led from the USA because it is the biggest market and environmental considerations started there. Since the introduction of lead as TEL* and TML* for octane boosting in the 1930s, there has been no single fuel quality issue as big as lead phase-out. Despite the oil industry's early protests, unleaded gasoline now fuels the highest performance production engines wherever it is demanded. Its sales vary enormously from country to country but not because of technical factors, merely political influence - or lack of it. (Appendix II)

unleaded established

*Tetraethyl lead
*Tetramethyl lead

....

In Europe, where most countries have some sort of emission legislation - usually based on EEC regulations - very little of it is related to local environmental conditions. Limits are not related to air quality standards and there is little, if any correlation between air quality and public health. poor correlation

Nevertheless, a relentless search for low-emission, fuel-efficient engines will continue because it makes good sense to avoid unpleasant odours and harsh noises. The quest will be followed everywhere, at a pace proportional to means. As with the diesel, a sophisticated approach has had to be adopted for injection systems. Electronic control and appropriate additive-treated fuels will be essential. (Appendix II) common sense

In the USA attention is focussed on so-called "Reformulated Gasoline" (Appendix II) This is tailor-made gasoline to suit low emission engines and is not unlike the change in diesel fuel quality that will be taking place in Europe for much the same reason. Reformulated Gasoline

Interesting developments are taking place on Specific Calorific Value in Europe, thanks to the links between leading oil companies and car manufacturers with an interest in the Formula 1 Grand Prix circuits. This will, no doubt, eventually have its impact on the production car. (Appendix II) Grand Prix Fuels

AVAILABILITY OF DIESEL AND GASOLINE.

For a couple of decades, only the transport sector has produced an increase in demand for petroleum fuels. In industry and power generation, demand has fallen due to a combination of improved efficency and the use of alternative energy sources. This shift in demand has "released" a great deal of crude oil for conversion into gasoline and diesel fuel and this trend will continue. demand will be met

The demand for transport fuels will probably remain stable at present levels because their efficient use is becoming increasingly recognised as a valuable contribution to reducing running costs. There is much that the fleet operator can do to reduce fuel consumption - in his own interest - and whatever he does will contribute to the overall "stretching" of crude reserves. (Ref.5) fuel economy

Reserves of crude oil are not dwindling -as some argue. Quite apart from new discoveries, existing fields are being made to yield more of the oil in the ground. Old wells are being re-worked and there is scope for more of this. The South African contribution on oil from coal, Brazil's work on alcohol fuels and the Venezuelan bitumen/water emulsion project are examples of new fuels that reduce the total demand for conventional materials. Recent work in the UK has shown coal to be a good raw material for low sulphur, low pour diesel. Natural gas reserves, now estimated as double crude-oil reserves, will make a substantial contribution to the fossil energy pool. crude oil reserves will last

Oil has now been found in granite, indicating that vast non-fossil fuel reserves may exist deep in the earth. If this is right, new techniques will be needed to obtain it. New techniques are always developed when there is a real need! non-fossil crude oil

....

ALTERNATIVE FUELS

In road transport, gases (and fuels or components made from gases) are already playing a role with about a million vehicles running on LPG, LNG and CNG - of which more will be said at this Seminar.

Despite doubts about the overall efficiency of the electric car (and its performance) there is a narrow sector of interest that will lift a few more vehicles out of the market for petrol and diesel fuel.

VW has produced more than two million sugar-cane-based alcohol-fueled engines in Brazil. Other biomass-based fuels, such as methanol from rape seed, wood or natural gas, are of growing interest.(Ref.1) Other biomass materials have a potential for producing both gasoline and diesel fuel.

contributions from new fuels

Hydrogen may also make a contribution if the use of nuclear energy needed to produce it is eventually acceptable to all, although there may be better uses for the hydrogen - and the nuclear energy.

It is doubtful whether any of the developments mentioned above (and others) will have much impact alone but, collectively, they will make a very useful contribution to fueling road transport until the ultimate alternative power source arrives.

collective impact

THE LONG TERM

A non-polluting, silent, fuel-efficient engine should result from the concentration of human resources on this common goal. Progress towards it will be slow because a reasonably acceptable alternative - in the form of the internal combustion engine - is available and tolerated. Already, solar energy is being captured and converted to electricity for powering space satellite equipment and experimental light vehicles. Bearing in mind the large area of solar cells necessary, some types of commercial vehicle would appear to offer useful flat surfaces for the purpose. Light harvesting is now claimed to absorb more sunlight than the green pigment in plants. For the doubters, there is the more believable prospect of the Fuel Cell being developed to convert gaseous fuel, maybe hydrogen, to electicity in the most environmentally friendly way of all - by producing pure water as its waste product.

It is hard to predict when or how "breakthroughs" of this sort may occur but, looking back, it is clear to see that they do occur, usually ahead of their time. They then wait "in the wings" until the traditional approach becomes unattainable or unacceptable.

.....Conclusion

CONCLUSION

Fuel quality and availability are closely linked. Trends in the production of crude oil and in the formulation of road transport fuels will do much to secure the desired quality without sacrificing volume.

The biggest single factor influencing fuel quality is environmental concern. There is little doubt that fuel quality requiremnts will be met for the sophisticated environmentally-friendly engines of the future. Traditional fuels will continue to be available where they satisfy local needs.

The "days of the diesel are not numbered" and there is no foreseeable date for "when the oil will run out". There are, however, good reasons for ensuring the efficient use of fuel - after it has been stored carefully to preserve its inherent good quality.

A more efficient, "clean" power source than the internal combustion engine will be needed in the long run for road transport and the direct use of solar energy looks the best, but very distant, contender.

.....Table 1

Appendices I & II

DRAFT CEN DIESEL FUEL SPECIFICATION

PROPERTIES APPLYING TO ALL GRADES			
FLASH POINT	°C	MIN	55
ASH	%m	MAX	0.01
WATER	mg/Kg	MAX	200
PARTICULATES	g/m^3	MAX	20
COPPER CORROSION	3h AT 50°C	MAX	1
OXIDATION STABILITY	g/m^3	MAX	25
SULPHUR	%m	MAX	0.20
CARBON RESIDUE	%m	MAX	0.30
EUROGRADES (GRADES 1 TO 6)			
CFPP	°C	MAX	+5/0/-5/-10/-15/-20
DENSITY AT 15°C	kg/m^3		820 - 860
VISCOSITY AT 40°C	cSt		2.00 - 4.50
CETANE NUMBER		MIN	49
CETANE INDEX		MIN	46
DISTILLATION:-	°C		
10% VOL REC AT			REPORT
50% " " "			REPORT
65% " " "		MIN	250
85% " " "		MAX	350
95% " " "		MAX	370

ARCTIC GRADES (GRADES 7 TO 10)						
GRADE			7	8	9	10
CFPP	°C	MAX	-26	-32	-38	-44
CLOUD POINT	°C	MAX	-16	-22	-28	-34
DENSITY AT 15°C	Kg/m^3	MIN	800	800	800	800
		MAX	845	845	840	840
VISCOSITY AT 40°C	cSt	MIN	1.50	1.50	1.40	1.20
		MAX	4.00	4.00	4.00	4.00
CETANE NUMBER		MIN	47	46	45	45
CETANE INDEX		MIN	46	46	43	42
DISTILLATION:-	°C					
10% VOL REC AT		MAX	180	180	180	180
50% " " "			REPORT	REPORT	REPORT	REPORT
95% " " "		MAX	340	340	340	340

Table 1 - Proposed European Diesel Fuel Specification.
(Reference 2)

APPENDIX I

FUEL SPECIFICS - DIESEL

The relative influence of European and American trends.

In the USA there are two classes of automtive diesel fuel, D1 and D2. The quality of D1, a kerosene-type fuel originally intended for the two-stroke diesel, was maintained during the '70s & '80s. D2, the general-purpose road transport fuel, deteriorated markedly due to the use of surplus residues from cracking processes to increase gasoline production. When the quality became unacceptable to operators they used D1, alone or blended with D2 and/or they used "after additives", for which a considerable market developed and continues.

In Europe there is only one class of automotive diesel fuel. It has not been, and will not be, allowed to deteriorate too far as there's no alternative - apart from the use of "after additives". Although it is difficult to generalise across Europe because attitudes vary nationally on this point, most users tend to be suspicious of additives offered direct to them and many quote costly adverse experiences. However, they seem to place an almost blind faith in additives if the refiner uses them! This attitude, coupled with oil-company interest in brand differentiation, has led to the marketing in quality-perceptive countries of Premium Diesel Fuels. It seems likely that they will grow in popularity and, as electronically-controlled fuel injection equipment becomes the norm, Premium Diesel will become the general-purpose fuel for modern automotive diesels. National Specs. are likely to reflect this in due course.

Premium Diesel Fuel

Modern diesel fuels are blended from:

- Naphtha
- Light Distillate
- Kerosene (a medium distillate)
- Heavy Distillate
- Catalytically-cracked derivative of heavy fuel oil
- Hydro-cracked oil
- Thermally cracked oil (not often used)
- Visbroken fuel (another cracking process)
- Gas condensates

Chemical additives are used in the blends to improve specific aspects of performance: see Table 1A. Because of the more precise need of the "clean" diesel and the wide selection of components available, new tests may soon be necessary to define quality. They are likely to involve chemical analyses rather than performance tests.

After-Additives

These are the materials sold to fleet operators for adding to purchased fuel in storage or vehicle tanks. They are usually the same basic materials as those used by refiners to meet specifications and control quality.

It is difficult to generalise over their use in either diesel fuel or gasoline.

> In areas with good quality fuels they are not needed and may do more harm than good in fuels that have already been adequately treated with carefully selected additives at the refineries.
>
> Where fuel quality is lacking they can be of considerable help if carefully chosen and applied correctly.

Clearly, local advice is needed on the quality of the untreated fuel and whether it will respond usefully and economically to appropriate additives.

APPENDIX II

FUEL SPECIFICS - GASOLINE

The relative influence of European and American gasoline trends.

Unleaded gasoline is now commonplace in North America and Europe. It was introduced in the USA to enable catalytic exhaust-gas convertors to work. In Europe it was introduced, somewhat later, to reduce the lead burden of the atmosphere.

Different reasons are again leading to a similar outcome with the formulation of gasoline for the future. In the States it has been led since the 1950s by California in an attempt to reduce its climatically and topographically-influenced pollution problem. The latest move to "cleaner fuel", (Reformulated Gasoline) has already been followed by ten states and probably three more will follow, although they don't have a Californian smog problem.

In Europe, the quest now is to mitigate the greenhouse gases, particularly carbon dioxide. Eleven European nations have agreed on a collective programme which extends beyond the automotive/road transport sector to industry and power generation. "Cleaner" gasoline will be needed to achieve the required emission levels and Europe may follow the States' "Reformulated" approach to achieve this.

Reformulated gasoline

This term is used to describe gasolines which are blended to reduce exhaust emissions caused by the fuel. They usually contain ethers or alcohols ie, having oxygen in addition to the hydrogen/carbon molecules in traditional gasoline blending components.

The reduced emissions result from their lower volatility and the role of the oxygen in reducing carbon monoxide. Some have lower aromatics, including benzene, and one is known to have a low olefin level. All have deposit-control additives to keep inlet systems clean - an essential feature if engine-created emissions are to be minimised. Additives to control combustion-chamber deposits are expected in order to meet future demands for even lower emissions and better fuel economy.

In addition to the conventional gasoline blending components from the distillation, cracking and reforming of crude oil, the following materials are used to enhance quality, volume - or both:

Butane
Benzene
Toluene
Methanol
Ethanol
Methyl Tertiary Butyl Ether (MTBE)
Tertiary Butyl Alcohol (TBA)
Tertiary Amyl Methyl Ether (TAME)
Nitromethane

Formula 1 Fuels

Fuels of high specific energy, ie high calorific value per unit of mass, are of interest to Grand Prix competitors to help increase output from given engine configurations. Increases of 6 - 8% are being mentioned. Shell for Honda/Maclaren, Elf for Renault/Williams and Agip for Ferrari have, allegedly, developed such fuels. The Agip fuel, called "Cubane", has been reported to have a carbon lattice structure with a carbon atom at each corner.

TYPE OF FUEL ADDITIVES		
ADDITIVE	**BENEFITS**	**PROBLEMS**
Flow Improvers Ethylene-vinyl acetate. Polyolefin Ester. Polyamide.	Modify wax crystals to minimise filter blocking as assessed by CFPP test.	None
Cetan Improvers Isopropyl nitrate. Amyl nitrate. Octyl nitrates. Hexyl nitrates.	Increase cetane number	Have no effect on cetane index
Dispersants Ashless polymers. Organic amines.	Control the size of particles that form if stability has not been ensured. May also remove insolubles from surfaces.	May dislodge gums and cause filter blocking — if not used regularly.
Deposit Modifiers (Detergents) Polyamines. Polyisobutene. Succinimides.	Keep combustion chamber surfaces clean. Can be used to clean-up too.	Some may form gums if used to excess.
Corrosion Inhibitors Alkyl phosphates. Prevent rusting of drums, storage and vehicle tanks.	Prevent rusting of drums, storage and vehicle tanks.	None
Anti-oxidants (Stabilisers) Surface-active sulphonates and polymers, alkylated phenol.	Inhibit the up-take of oxygen to avoid formulation of insolubles, (gums sludges and sediments).	Must be used early after refining for best effect (while fuel is hot).
Multi-purpose Mixtures of anti-oxidants and dispersants. May include corrosion inhibitors and water emulsifiers.	General purpose, according to individual description. Generally favoured for severely unstable fuels.	Can be relatively expensive if all properties not needed.

In addition to the additives detailed above, the following are used by refiners to deal with specific properties:

Anti-static Additives

Anti-foams

De-hazers

Lubricity Improvers

Biocides

Re-odorants

Table 1A

LIST OF REFERENCES

1. Interview with Dr Carl Hahn, Chairman of Volkswagen. BP Shield, Autumn 1991.

2. Development of Diesel Fuels for the Market. Dr L J Rainbow CChem MRSC & Mr E L Marshall CEng MIMechE, BP Research Centre. Paper presented to the IMechE Fuels, Lubricants & the Operator Seminar, 4th December 1991.

3. The A - Z of Good Fleet Housekeeping. Mr R Denniss CEng MIMechE FIRTE, Consultant, Lorry Logic. Paper presented to the IMechE Fuels, Lubricants & the Operator Seminar, 4th December 1991.

4. Alternative-fuel Lessons from South Africa. J D Savage CEng FIMechE HonFIRTE MSAE, Fuels & Lubricants Specialist. Article in "Transport Engineer", July 1988.

5. Improving Operating Economics of Commercial Vehicles. IMechE/IRTE Seminar, 7th February 1991.

Useful up-dates on fuel trends are given in "Fuel Review" in the Associated Octel Company Ltd publication "Fuel News" (e.g. December 1991)