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effects of the introduction of unleaded gasolines on the gasoline storage/distribution system

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ABSTRACT

The report reviews the factors to be taken into account when assessing the effects of superimposing one, or two, unleaded gasoline grades on the existing leaded gasoline storage/distribution system. It also considers the consequences for both the oil industry and the motorist throughout the introductory and transitional phases until only unleaded gasoline is required.

Het rapport overziet de factoren waarmede rekening gehouden moet worden wanneer, in aanvulling op de reeds aanwezige soorten benzines, één of twee loodvrije benzines in het bestaande benzine opslag- en distributiesysteem gebracht worden. Het rapport beschrijft tevens de consequenties voor de olie industrie zowel als voor de automobilist tijdens de introductie periode en daaropvolgende overgangsfasen totdat uitsluitend loodvrije benzine nodig zal zijn.

Der Bericht betrachtet die Einflussgrössen auf das Lager- und Verteilungssystem bei der Einführung von ein oder zwei Sorten von unverbleitem Kraftstoff zusätzlich zu den bisherigen verbleiten Sorten berücksichtigt werden müssen. Auch über die Auswirkungen in der Anfangs- und Übergangsphase bis zum vollen Übergang zu unverbleitem Kraftstoff werden für die Mineralölindustrie und den Autofahrer berichtet.

Le rapport passe en revue les facteurs à prendre en compte quand on évalue les effects de surimposer une ou deux qualités d'essence sans plomh sur le système existant de stockage et de distribution de l'essence avec plomb. Il considère aussi les conséquences à la fois pour l'industrie pétrolière et pour l'automobiliste pendant toutes les phases d'introduction et de transition jusqu'à ce que seulement de l'essence sans plomb soit exigée.

El informe estudia los factores a tener en cuenta a la hora de evaluar los efectos que resultan de sobreponer uno o dos grados de gasolina exenta de plomo, al sistema existente de almacenamiento/distribución de gasolina con plomo. Toma también en consideración las consecuencias de ello, tanto para la industria petrolera, como para el conductor, a lo largo de las fases de introducción y de transición, hasta illegar a la fase en que solo se necesita gasolina exenta de plomo.

Il rapporto passa in rassegna i fattori da tenere in considerazione nella valutazione degli effetti causati dalla agguinta di uno o più tipi di benzina non etilata nei sistemi di distribuzione/immagazzinamento di benzine etilate. Vengono inoltre presi in considerazione le conseguenze, sia per l'industria petrolifera, che per l'automobilista, nelle fasi di introduzione e di transizione precedenti a quella in cui sarà richiesta esclusivamente benzina non etilata.

SUMMARY

1. The availability of leaded gasolines will have to be maintained for 10-15 years after cessation of production of cars requiring them. Therefore, the production and distribution of unleaded gasolines will initially be superimposed on the existing production and distribution system.

1.2 CONSEQUENCES FOR THE OIL INDUSTRY (SUMMARY)

The demand for gasoline in EEC has been, and is expected to remain, relatively constant. In practice the existing storage tanks in use at refineries/blending installations and throughout the distribution system for leaded gasolines are dedicated to a particular grade for operational reasons. Although some tankage may be available, it should not be assumed that there is significant excess capacity in the existing system which could be used for unleaded gasoline which should be handled separately from the leaded grades during the transition to a totally unleaded market.

Consequently, there will be a need for investment for storage tanks at refineries/blending plants and throughout the distribution system to accomodate any additional unleaded grades.

In cases where existing tankage is available to store and distribute unleaded gasoline, a minimum advance notice of 18 months will be essential to allow the industry sufficient time to drain, clean and convert the facilities into a segregated system for distributing unleaded gasoline meeting a mandatory "lead-free" (0.013 gPb/l max) requirement.

If new installations are required, a longer period of time may be required to design and obtain planning permission for the installation, its fabrication and construction.

Account should also be taken of the time required to dispose of any strategic stocks of leaded gasoline held in the various countries.

Some investment will also be required in the transportation sector for additional road/rail tankcars and possibly barges.

The magnitude of the investment will depend on the total number of grades to be distributed (leaded and unleaded) and whether strict limits are placed on lead contamination of unleaded fuels to protect lead sensitive control systems fitted to new vehicles.

The lowest investment/costs for the oil industry in the distribution system would be associated with the introduction of only one unleaded grade in place of the current Regular Grade. However, this situation would require a substantial increase in the refinery pool octane number, particularly in countries with a high demand for leaded Regular Grade.

The highest costs would be incurred if two unleaded grades were added to the existing supply pattern, making a total of four grades to be distributed during the introductory phase.

Depending on the demand growth for unleaded gasoline, decisions may need to be made during the transitional period concerning the distribution and availability of the leaded grades.

Since no significant growth in total gasoline demand is expected in the foreseeable future, a considerable part of the system installed to accommodate both leaded and unleaded gasoline be under-utilised throughout the transition period and will become superfluous at the end of the transition period when only unleaded fuel is required.

There are substantial differences between Member States concerning the current demand pattern for leaded Premium/Regular gasolines and also in the configurations of the existing distribution systems. This, combined with the uncertainties about the number of grades to be distributed and the initial and developing demand for the new grades, makes it impossible to assess the total investment required in EEC.

It should be noted that small service stations with limited land availability could not accommodate the tankage for additional gasoline grades. Also the initial low rate of throughput for unleaded gasoline could make the substitution of one leaded grade by an unleaded grade commercially unattractive. Such sites might be unable to offer the full range of grades potentially required by the motorist with detrimental consequences for their economic viability.

1.3 CONSEQUENCES FOR THE CONSUMER (SUMMARY)

The additional investment costs for distribution will need to be recovered from the consumer as well as the increased manufacturing cost for unleaded gasoline. However, for the reasons given in section 1.2 above, it is not possible to derive a figure for increased cost due to the distribution system.

There are three particular aspects of fuel availability:-

a) During the introductory phase, it may be that unleaded gasoline will not be available at all service stations, especially the smaller ones, and drivers of cars designed for unleaded fuels may encounter some inconvenience. However, provided that the car is not fitted with lead sensitive emission control devices, and that the manufacturers warranty allows, leaded fuel could be used in emergency.
b) Conversely, especially toward the end of the transition to a totally unleaded gasoline market, the drivers of cars requiring leaded fuels will encounter similar difficulties.

c) In cases where leaded Regular Grade is replaced by an unleaded gasoline grade, owners of cars requiring leaded Regular will be obliged either to:

- use leaded Premium Grade, or
- tank with an appropriate mixture of unleaded Regular and leaded Premium , if advised by the car manufacturer (and within the terms of the warranty). In each case he may incur additional fuel costs compared to the normal use of leaded Regular.

During the period when both leaded and unleaded fuels are available on the market, motorists will need to exercise care to use the correct type of fuel to avoid engine damage and avoid violating the manufacturers warranty terms. This applies equally to:

- the prevention of cars requiring leaded fuel being consistently fuelled with unleaded gasoline, and

- the prevention of cars fitted with lead-sensitive emission control devices being fuelled with leaded gasoline.

The only physical way to avoid both possibilities would be to use a non-circular filler pipe on new cars with a matching nozzle on the dispenser pump.

2. INTRODUCTION

The additional fuel cost incurred by motorists due to the use of unleaded gasoline has three components:

a) The additional cost at the refinery due to the manufacturing process,

b) The change in vehicle fuel consumption to cover the same mileage,

c) The additional costs due to the installation and operation of the necessary blending/storage facilities at the refinery, and changes in the distribution system from the refinery and including the service stations.

Additional costs for a) and b) are given as a combined figure in CONCAWE Report No. 11/83R.

The costs under c) will show a discontinuity from the introduction of unleaded gasoline, through the transitional period until only unleaded gasoline is marketed.

Since gasoline demand is not expected to increase significantly over the period concerned, the investments to be made by the oil industry for handling unleaded gasoline are relevant only to the introductory and transitional periods and will become obsolete when only unleaded gasolines are marketed. At that time, the distribution system is likely to resemble the current system in terms of capacity.

The level of the additional investment and operating costs in the introductory phase will depend on the number of leaded and unleaded grades to be distributed and the level of demand for each of them. Further, investment during the transitional period will depend on the rate of change in demand for the unleaded fuels and decisions to introduce - or delete - one or more grades from the market.

There are important differences in the distribution system for existing grades between the EEC Member States at present (e.g. in some countries large volumes are distributed by barge and coastal tanker) which will have a significant effect on the level of investment necessary and, consequently, cost to the motorist.

Due to the large number of variables involved, it is not possible to arrive at a total additional investment for the unleaded gasoline distribution system in EEC. The following reviews factors which must be taken into account when assessing the impact of distributing unleaded gasolines and provides unit investment costs for the items of equipment required in the refinery and the distribution system.

3. CURRENT GASOLINE PRODUCTION, STORAGE AND DISTRIBUTION SYSTEM

The production and distribution of unleaded gasoline will have to be superimposed on the existing system since leaded gasoline must continue to be available for the existing vehicle population. Most EEC Member States have, currently, a two grade system for leaded gasoline, i.e. a premium grade and a regular grade. However, some countries do have a third grade, or use "mixer pumps" at the service station to allow blending of grades between the premium and regular qualities. The ratio of demand between premium and regular varies in each country depending on the characteristics of the vehicle population and customer driving/buying habits. The volumes and ratios consumed in 1981/2 are shown in Table 1.

Gasolines are, in the main, blended and stored at oil refineries pending dispatch, although gasoline may be blended at other installations from components imported from diverse manufacturing sources.

From the refinery blending installation, the gasolines are dispatched by coastal ship, barge, pipeline , road tanker or block train to terminal storage depots. These intermediate distribution terminals are equipped with one - or more - tanks for each grade of gasoline, depending on throughput.

At the terminal the separate grades are discharged into road tankers through appropriate loading arms for delivery to the service stations.

The road tankers vary in capacity and may be separated into compartments which contain different grades of gasoline in one load.

Service stations have one - or more - underground tanks for each grade with appropriate dispenser pumps.

The production of gasoline is geared to the demand for that product in balance with the demand for other petroleum products (e.g. fuel oils) both of which may be variable and seasonal. Adequate storage capacity must be available at the refinery/blending installation, and throughout the distribution system, to accomodate these variations and a minimum stock level of each gasoline grade must be maintained at all storage points to ensure continuity of supplies to the consumer.

Consequently these storage tanks are rarely emptied - except for essential maintenance - and each one is, in effect, dedicated to the storage of a particular gasoline grade. Thus, the configuration of the storage/distribution system is related mainly to the number of grades to be supplied with the actual level of throughput being a secondary factor.

It should be noted that EEC gasoline demand and the number of grades offered on the market have been - and were projected to remain - almost constant. The introduction of unleaded gasoline will not significantly change total gasoline demand but, depending on the route chosen, may increase the number of grades to be marketed during the introductory and transitional periods.

Therefore, the introduction of additional grades will require the installation of new tankage, transfer piping and loading facilities at refineries/blending plants, distribution depots and many service stations. Although initial demand for the new grades will be relatively small, the capacities of the new tanks will be selected taking account of expected growth in demand and the economies in cost related to the capacity of individual tanks.

This additional storage will represent a segregated system for unleaded (essentially "lead-free") gasoline.

4. UNLEADED/LEAD-FREE GASOLINE

The above terms, particularly "unleaded", are used in different ways in some countries. A clear distinction between them is necessary when discussing the possible impact on the distribution system of introducing unleaded gasoline and during the transition to a totally unleaded market. For the purpose of the following discussion these terms are defined as follows:

- Unleaded gasoline is simply gasoline to which no lead compounds have been intentionally added, but which may be subject to lead contamination during distribution in a system also transferring leaded fuels.

- "Lead-free gasoline", to which no lead has been added intentionally but for which a maximum trace lead content (less than 0.013 gPb/l in the US) is defined to avoid damage to lead sensitive control devices in emission controlled cars. This is termed unleaded gasoline in U.S. legislation. To meet this specification, some experience in the US has shown that a degree of segregation from leaded gasolines is necessary in the distribution system and particularly at the refinery.

  The term "lead-free" can be misleading since it is not possible to guarantee completely lead-free gasoline in chemical terms.

  In the following discussion, unleaded gasoline is used as a general term and "lead-free" is indicated only when it may have a significant impact on the matter under discussion.

5. INTRODUCTORY ALTERNATIVES

Four alternatives are conceivable for the introduction of unleaded gasoline:

Case	Unleaded grades	Leaded grades of grades	Total number
A	1	LP	2
B	1	LP and LR	3
C	2	LP	3
D	2	LP and LR	4

where LP = Leaded Premium
LR = Leaded Regular

Cases A and C involve the substitution of leaded Regular by an unleaded grade. For cases B and D, unleaded gasoline is introduced as additional grades.

The number of alternatives is constrained by the requirements that at least leaded premium must continue to be available for existing vehicles.

The actual choice of a route for introduction will depend on many factors, including in particular the current grade structure and the existing distribution network. Consequently, given the differences between individual countries, it should not be assumed that the same route would be taken in each country.

6. DEMAND

The initial demand and growth in demand for unleaded gasoline are important factors during the transitional period. This demand would depend on two factors:

- rate of introduction of new cars requiring unleaded gasoline, and
- the number of existing cars which will use the unleaded fuel

Due to the multitude of variables which influence the two basic factors, it is not possible to predict with any accuracy what this demand will be. Certainly, two important considerations will be the price of both new vehicles and unleaded gasoline relative to leaded gasoline, and the guarantee question of existing cars designed for leaded fuel running on unleaded gasoline.

Consequently, these uncertainties over demand for the new fuel add further to the problems of analysing the transition period, and underline that the consequences can only be discussed in general terms.

7. CONSEQUENCES FOR THE OIL INDUSTRY

The previous sections have described the existing system and identified the following important factors:

- Total number of grades
- Unleaded or "lead-free" gasoline,
- Initial demand and growth in demand for unleaded fuel.

The total number of grades is the most critical factor for all aspects of the refinery storage and distribution network. The lower the number of grades, the lower the costs since we currently have a network designed for two grades i.e. case D with four grades which give very high extra costs whilst case A with two grades would be the lowest cost option.

7.1 REFINERY STORAGE/DISPATCH

Whether the gasoline is defined as unleaded or "lead-free", in effect, segregated blending and dispatch systems will be required during the transition period for the reason given in section 3. The extent to which existing tankage and associated facilities can be made available for additional gasoline grades will depend on the specific circumstances of each refinery.

Consideration will need to be given to the problem of contamination if tankage previously used for leaded gasoline is allocated to an unleaded grade (see section 7.8 below)

7.2 DISTRIBUTION DEPOTS

Similar considerations to those in section 7.1 apply to the storage of unleaded gasolines at intermediate distribution terminals.

7.3 SERVICE STATIONS

Many small service station sites with limited land availability, or restrictions on the quantity of fuel which may be stored for safety reasons, will be physically incapable of handling four grades. Also, the initial low rate of throughput for unleaded gasoline could make the substitution of one leaded grade by an unleaded grade commercially unattractive. Such sites might be unable to offer the full range of grades potentially required by the motorist with detrimental consequences for their economic viability and continued operation.

7.4 ULTIMATE SITUATION

Since no significant growth in total gasoline demand is expected in the foreseeable future, a considerable part of the storage/distribution system installed to accommodate both leaded and unleaded gasolines will become superfluous at the end of the transition period when only unleaded fuels are required.

The extent of this wasted investment will be largely dependent on the number of grades to be offered during the introductory and transitional period.

7.5 GASOLINE DELIVERY

The transportation of unleaded gasoline will result in higher operating costs for distribution by road, rail, barge etc., and may require provision of additional road tankcars, particularly if "lead-free" gasoline is required. Although the dilution factor (i.e. volume of unleaded cargo/residue of previous leaded cargo) may indicate that tankers may be used interchangeably for leaded and unleaded grades, quality guarantee and liability considerations will probably result in transport equipment/compartments being dedicated to unleaded fuels, if only to minimise the risk of mistakes.

7.6 REFINING

Whilst the substitution of leaded Regular by an unleaded grade (cases A and C) minimises additional distribution costs, it can have major implications for the refinery. When leaded Regular is substituted, those motorists currently buying this grade will have to use either leaded Premium or, if their car is compatible, unleaded gasoline. Either way, there will be an increase in the pool octane number the refinery has to produce. Where there is currently a high market share for leaded Regular, there could be a significant jump in octane demand leading to supply problems for high octane grades.

7.7. MISFUELLING

There are two aspects of this problem:

a) To prevent cars requiring leaded fuels being consistently fuelled with unleaded gasoline, leading to increased engine wear.

b) To prevent cars fitted with lead sensitive emission control devices being fuelled with leaded gasoline resulting in ineffective emission control.

If both aspects have to be covered, this can only be physically achieved by using a non-circular filler pipe on the new cars and nozzle on the dispensing pumps. However, this would prevent existing technically compatible vehicles from using unleaded gasoline.

As already discussed, it is not possible to make any estimate of overall EEC costs for the various cases. However, for a perspective, Table 2 shows unit investment costs for the relevant parts of a distribution network.

7.8. TIMING

If excess tankage is available at refineries, distribution terminals, etc., or if an unleaded grade is substituted for a leaded grade on the market, it will be necessary to purge the storage/distribution system to be able to ensure "lead-free" quality at the service station pump, if required. The purged system will then have to be dedicated to the supply of unleaded gasoline and segregation carefully maintained during the transitional period when leaded gasoline is still being distributed.

Experience in the US has indicated that if storage tanks and transfer lines are correctly drained and any tank bottom sludges removed, the passage of a few deliveries of unleaded fuel should be adequate to ensure "lead-free" (0.013 gPb/l max.) at the service station dispenser.

The establishment of a quality assurance system at the refinery and throughout the distribution system, with training programmes for tanker drivers/service station operators, will probably be necessary to ensure the integrity of the unleaded system throughout the transitional period when leaded fuels are still in use.

The US experience indicates that after drainage and any necessary tank cleaning, a period of 3 to 6 months operation on unleaded fuel should be adequate to ensure "lead-free" quality at the service stations.

However, to allow industry to implement the drainage and cleaning programme, and to make any necessary engineering changes to develop a segregated system, at least 18 months notice of any mandatory date for the provision of "lead-free" fuel is essential.

The costs involved in the cleaning programme will be dependent on the specific circumstances and cannot be evaluated in this paper.

If new installations are required, a longer period of time may be necessary to design and obtain planning permission for the installation, its fabrication and installation. This could be important with respect to those service stations where inadequate facilities are currently available and where land availability is restricted, e.g. urban sites.

Account should also be taken of the time required to dispose of any strategic stocks of leaded gasoline held in the various countries, and the provision of facilities to store similar quantities of unleaded gasoline. However, depending on the characteristics of existing strategic stocks and the purpose for which they are intended, their substitution by unleaded gasoline may be phased over the transitional period.

8. CONSEQUENCES FOR THE CONSUMER

The impact of the introduction of unleaded gasolines on the consumer is difficult to evaluate. It will depend on the grade structure for leaded and unleaded gasolines in the introductory and transitional phases. As stated earlier, the overall impact cannot be evaluated because of the large number of undetermined variables. The geographical availability of the various grades may be limited in some cases.

8.1 INTRODUCTORY PHASE

Impact on the consumer depends on the decisions taken on the number of grades to be marketed.

During this period, it is improbable that unleaded gasoline will be available at all service stations except, perhaps, in case A. In case C, only one unleaded grade would be available at many sites. In the two substitutional cases (A and C), owners of cars requiring leaded Regular grade will be obliged either to:

- Use leaded Premium grade gasoline, or
- Tank with a mixture of unleaded Regular and leaded Premium at appropriate ratios/frequencies if advised by the car manufacturer. This solution could be frustrated by the installation of special nozzles to avoid mis-fuelling.

8.2 TRANSITIONAL PHASE

During the transitional phases, fuel distributors will make decisions on which leaded/unleaded grades can be made economically available at various sites. This will result in an inversion of the problems encountered by the owners of cars designed for unleaded/lead-free gasoline, or for the leaded regular grade vehicles. Owners of cars requiring leaded fuels will find it progressively more difficult to obtain those fuels.

9. DISTRIBUTION OF LOW-LEAD CONTENT GASOLINES

The reduction of permissible lead contents to 0.15 gPb/l in existing gasoline grades requires no additional investment for storage and distribution. Thus, additional costs to the motorist will be only those related to the manufacturing process.

Table 1 1981-82 EEC Gasoline market

COUNTRY	GASOLINE CONSUMPTION (x 1,000 t)	SHARE TOTAL EEC (%)	PREMIUM SHARE (%)	PREMIUM GRADE		REGULAR GRADE	
				MAX LEAD LIMIT		MAX LEAD LIMIT	
				RON	gPb/l	RON	gPb/l
BELGIUM	2,623	3.2	90	98-99	0.4	90-93	0.4
DENMARK	1,332	1.6	63	98	0.4	92	0.15
EIRE	986	1.1	90	97	0.4	90	0.4
FRANCE	17,936	22.0	84.5	97-99	0.4	89-91	0.4
FED. REPUBLIC	22,731	27.7	54	98-99	0.15	91-94	0.15
GREECE	1,480	1.7	71	96-98	0.4	90	0.4
ITALY	11,960	14.5	95	97-98	0.4	85-86	0.4
LUXEMBOURG	297	0.4	93	98-99	0.4	90-93	0.4
NETHERLANDS	3,582	4.3	79	98-99	0.4	91-93	0.4
UK	19,247	23.5	86	97-98	0.4	90	0.4
TOTAL-EEC	82,174	100.0	77	-	-	-	-

Virtually all gasolines surveyed are reported to be at max. allowable limit.

Table 2 Unit investment costs for storage/distribution equipment. (All costs in 1983 US$)

Equipment	Capacity	Costs
Storage/blending tanks, including associated piping	5 - 20,000 m^3	80-150 US$/$m^3$
Road tanker	35 m^3	50,000-100,000
Extra truck loading system (rack, piping, meters, loading-arms)		100,000-120,000
Service station tank with associated piping and dispenser pump		15,000- 20,000
Nozzles for dispenser pumps		100-150