DRIVEABILITY INDEX OF COMMERCIAL GASOLINE IN ASEAN COUNTRIES

by
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I. INTRODUCTION

Motor gasoline is essentialy a complex mixture of hydrocarbons distilling between about 40°C and 225°C and consisting of compounds generaly in the range C_5 to C_{12}. Small amounts of additives are also used to exchange various aspects of the performance of the fuel. Gasoline produced from different refineries can vary widely in compositions, even at the same octane level.

The primary requirement of a gasoline is that should burn smoothly without exploding, under the conditions existing in the combustion chamber of the spark-ignition, so that themaximum amount of useful energy is liberated[1].

The volatility of a gasoline has a vital influence on the both performance of a car emission. It affects the way car starts, the time it takes to warm up, the exten to which ice will form in the carburator, causing stalling and other problems; it influences vapour lock in the fuel system and indirectly it determines overall fuel economy. Volatility is a measure of the ability of a fuel to pass from the liquid to the vapour state under varying conditions.

In cold weather, cars can take a very significant time to warm-up *i.e*., be capable of smooth, non-hesitating accelerations without the use of the choke. The fuel parameter that is found to have the grestest influence on warm-up is the mid-boiling range volatility as characterized by for example; the 50 per cent distillation temperature. Even after the car has warmed-up, fuel volatility can still have an influence on acceleration time. Low volatility fuels obviously give leaner mixture and as mixtures leaner, acceleration performance can fall off quite rapidly. The fraction of the fuel that influences acceleration behaviour to the greatest extent is in the mid and to a lesser extent the higher boiling range. Thus, the 50% distillation temperature, sometimes together with the 90% distillation, must be controlled to ensure optimum acceleration behaviour.

The factors which influence vapour lock is the volatility characteristics of the fuel. The degree to which a fuel is liable to give vapour lock depends mainly on its front end volatility. A number of different front-end volatility parameters have been used to define the vapour locking tendency of a fuel, such as RVP, percentage evaporated at 70°C, the 10 and 15% slope of the distillation curve, the vapour/liquid ratio at a given temperature and pressure. These distillation characteristics affect the following performance characteristics: starting, vapour lock and driveability.

ASTM D4814-98a the standard specification for Automotive Spark-Ignition Engine Fuel has included Driveability Index as an item of performance requirement of the fuel. The inclusion of the parameter is to provide control of distillation parameters that influence cold start and warm up driveabilities.

II. DRIVEABILITY INDEX OF GASOLINE

The ASTM Driveability Task Force has previously determined from data collected by Coordinating Research Council (CRC) and others that a relationship exists between fuel distribution temperatures and vehicle cold start and warm up driveability performance. This relationship can be expected by a Driveability Demerit model that can estimate vehicle driveability demerits during cold start and warm up conditions. The predictive model is a function of ambient temperature and fuel volatility expresses as the distillation temperature at which 10%, 50%, and 90% by volume of the fuel is evaporated.

ASTM D4814 volatility standards have typically provided satisfactory driveability in most vehicles [2]. The following DI equation (details in SAE Paper

881668) was developed by ASTM Driveability Task Force to related vehicle cold start driveability to gasoline distillation temperature based on data from several oil companies and the CRC programmes : as follows,

$$DI = (1.5 \times T_{10}) + (3.0 \times T_{50}) + (1.0 c T_{90})$$

where;

- T_{10}, T_{50} and T_{90} : distillation temperature °C(F) at 10%, 50% and 90% evaporated by test method ASTM D86, respectively.
- Temperature conversion: DLc = (DIr - 176)11.8.

Based on these data. proposed ASTM limit for driveability index is 1250°F (597°C) and 1200°F (569°C) for summer and winter seasons respectively (Table 1) [2].

Automakers. i.e. American Automobile Malnufacturers Association (AAMA), European Automobile Manufacturers Association (ACEA), Engine Manufacturers Association (EMA) and Japan Automobile Manufaturers Association (JAMA) have made an oxygenate correction for driveability index equation, i.e.,

$$DI = (1.5 \times T_{10}) + (3.0 \times T_{50}) + (1.0 \times T_{90}) + (11.0 \times Oxy\ wt.\%)$$

Table I
Vapour pressure and distillation class requirements

Class	AA	A	B	C	D	E
Vapour Pressure, kPa	54	62	69	79	93	103
TIO, °C, max	70	70	65	60	55	50
T50, °C	77 - 121	77 - 121	77 - 118	77 - 116	66 - 113	66 - \10
T90, °C	190	190	190	185	185	185
EP, °C max	225	225	225	225	225	225
D.I., max	597	597	591	586	580	569

Note:
Classes AA/A and D for summer and winter respectively, and Classes B, C and E for spring fall months

Table 2
Volatility of worldwide gasoline harmonization

Class	A	B	C	D	E
Temp. Range, °C	> 15	5 to 15	-5 to +5	-5to-15	< -15
Vapour Pressure, kPa	45-60	55 - 70	65 - 80	75 - 90	85 - 105
TIO, °C, max	65	60	55	50	45
T50, °C	77-100	77 - 100	77 - 100	77 - 100	77 - 100
T90, °C	130- 175	130-175	130 - 175	130-175	130- 175
EP, °C max	195	195	195	195	195
E70, %	15-45	20 - 45	25 - 45	25 - 47	25 - 47
EIOO, %	50-65	50 - 65	50 - 65	55 - 70	55 - 70
E180, % min	90	90	90	90	90
D.I., max	570	565	560	555	550

Note:
Classes A and D for summer and winter respectively, and Classes B. C and E for spring and fall months

Table 3
Volatility Specification of Commercial Gasoline in ASEAN Countries

Property Distillation, °C	Brunei Darussalam	Indonesia	Malaysia	Philippines	Singapore	Thailand	Vietnam
10%, cvap., max	60*	74	74	70	74	70	70
50% evap., min	117*	88	75	75	85	0	120
max	-	125	115	121	120	110	-
90% cvap., max	165	180	180	185	190	170	-
End Point, max	210	205	215	221	225	200	210
Rcsiduc, % vol. max	2.0	2.0	2.0	2.0	2.0	2.0	-
RVP at 37.8°C, kPa max	-	62	70	8.5	70	82	83

* Estimated li'om IBP, E70, EIOO, EI80 and FBP

World-wide gasoline harmonisation for summer gasoline recommended a driveability index (DI) limit of 569.

A. *World-Wide Gasoline Hannonisation*

AAMA, ACEA, EMA and JAMA offer world-wide fuel specifications and have established world-wide gasoline harmonisation for the benefit of their costumers and global motoring public. There are three categories of gasoline qualities have been recommended, as follows:

- Category 1

  Markets with no or minimal requiments for emission controls; based primary on fundamental vehicle/engine performance concerns.

- Category 2

  Markets with stringent requirements for emission control or other market demands.

- Category 3

  Markets with advanced requirement for emission control or other marked demands.

Each category is divided into five classes, *i.e*. A for summer class. D for winter-class and B, C and E for spring and fall classes. Driveability index for the categories 2 and 3 gasoline are 570, 565, 560, 555 and 550 for class A, B, C, D and E respectively. Limit of driveability index gasolines are 570 and 550 for summer and winter periods respectively (Table 2) [3].

B. *Commercial Gasoline in ASEAN Countries*

Volatility specifications of commercial gasolines in ASEAN countries are shown in Table 3 [5,6]. Based on the specification figures, the driveability index of these commercial gasolines are as follow:

Brunei Darussalam 606; Indonesia 555-660 (av. 610.5); Malaysia 555-636 (av. 595.5); Philippines 521-653 (av. 587); Singapore 556-636 (av. 607.5); Thailand 485-605 (av. 545) and Vietnam 655. driveability index of ASEAN commercial gasoline is as higher (except-Thailand) than proposed by both ASTM D4814 and world-wide fuel harmonisation.

There is a relationship between driveability index and RVP of gasoline and gasoline components. Driveability index of gasoline components are as follows: straight-runlight naphtha 543-555 (av. 549), cat. cracked gasoline 538-592 (av. 565), hydrocracked light naphtha 545-568 (av. 556.5), reformate 691-759 (av. 725), isomerate <235, alkylate 443-568 (av. 505.5) and polygasoline 602-639 (av. 620.5) [5].

Very view gasoline components fit these DI and RVP specifications well. Only alkylate, isomerate and cat. cracked gasolines which satisfy the requirement. The high proportions of refonnate in the gasoline pools in ASEAN refineries gives high driveability index (Table 4)[7]. Without blending more alkylate and isomerate in the gasoline pools, a RVP and Dl requirements can be quite difficult for refiners to meet. In addition, the dilution effect of these gasoline components (alkylate and isomerate) is also evident by the reduction in aromatics, olefins and sulfur content and octane capacity of these gasoline pools as compared to the cases where the alkylate and isomerate are limited. Proportion of gasoline components (alkylate and Isomerate) for reformulated gasoline in

Table 4
Compositions of gasoline components of commercial ASEAN gasoline and reformulated gasoline

Gasoline Components	Brunei Darussalam	Indonesia	Malaysia	Philippines	Singapore	Thailand	Vietnam	Reform. Gasoline
Cal. Cracked Gasoline	-	41. 54	-	37.14	17.75	28.12	25.61	38.0
Relormate	100.0	47.09	87.60	62.86	74.92	59.41	65.0	37.0
Isomerate	-		12.40	-	4.74	12.47	5.75	11.0
Alkylate	-	0.72	-	-	-	-	0.18	14.0
Polymer Gasoline	-	1065	-	-	259	-	3.46	-
Total	-	100.0	100.0	100.0	100.0	100.0	100.0	100.0

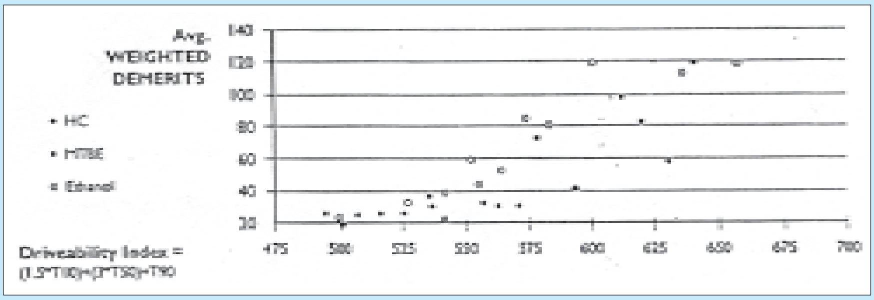

Figure 1
Effect of driveability index on driveability

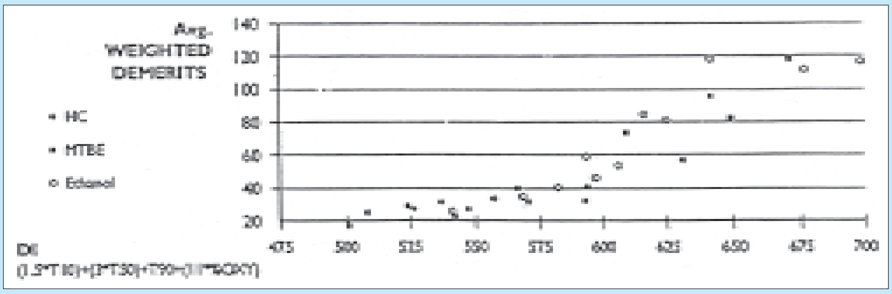

Figure 2
Effect of DI on driveability (oxygen corrected)

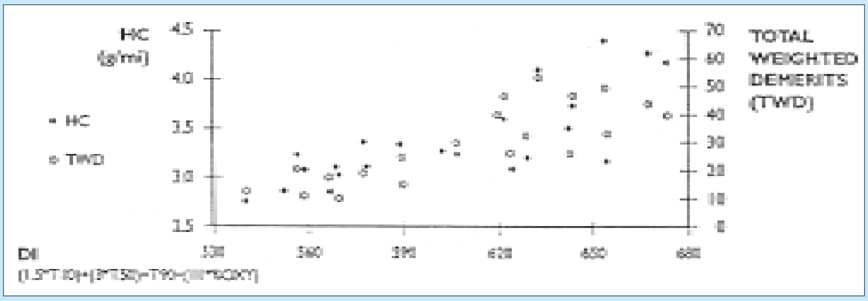

Figure 3
Effect of DI on driveability and exhaust emissions

the U.S. gasoline pools 1995 is about 24% vol. (Tabel 4) [8].

Recent CRC programmes have confirmed the relationship between Dl and vehicle performance. In addition, costumer tests conducted by CRC and Sun Company have determined that fuels in the 597 DC DI range cause increase consumer dissatisfaction. Consumer complains about cold start and warmup driveability using 597 and 624 DI fuels. Driveability was acceptable when they were replaced with 513 and 558 DI fuels.

Vehicle cold start and and warm-up driveability problems can occur when the Dl of summer gasoline exceeds 569, especially during the fall and spring transition periods. It has established a 570 DI maximum limit with an oxygenate correction for assembly plant gasolines to decrease the likelihood of high DI gasolines causing driveability problems and interrupting vehicles productions.

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Warm up driveability problems become more prevalent as the fuel 01 exceeds 569, and become more common and more severe above 597 D1.

Driveability concerns are measured as demerits. The test results from a recent CRC study which tested 29 test fuels: 9 all hydrocarbon, II with 10% ethanol and 9 with 15% MTBE are given in Figure 1.[3]. The data indicate that driveability problems increase for all types as DI increases, At D1 levels higher than those specified in this charter (550-570) driveability concerns increase dramatically. An oxygen correction factor is required to correct for higher driveability demerits for oxygenated fuel as compared to all - HC series. How the correction factor smooths the delta presented are shown in Figure 2.[3]. The driveability index is also drirectly related to tailpipe HC-emission, as shown in Figure 3.[3].

The driveability demerits were a non-linear function of fuel volatility and that the volatility effects varied for the hydrocarbon, MTBE and ethanol series.

III. CONCLUSION

In general Driveability Index (01) of all commercial gasoline in ASEAN countries is higher than those proposed ASTM D 4814 (01 596) and world-wide gasoline harmonization of summer gasoline quality (DI 570). In order to get the suitable driveability index, the composition of gasoline components in the gasoline pools must be improved by increasing the proportion of isomerate and alkylate components.

It has been found the relationship between DI and vehicle performance. Oriveability are measured as demerits. The driveability demerits were a nonlinear function of fuel volatility and that the volatility effects varied for the hydrocarbon, MTBE and ethanol series.

If a driveability specification is to be imposed on gasoline fuels, it should be the widest possible range of driving conditions (drivers. locations, driving patterns, vehicle types and model years etc.), not solely through evaluation by a group of only four or five trained raters traversing a short course and performing a rigid set of vehicle maneuvers using arelatively narrow slice of the vehicle population.

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