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UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

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THE DEVELOPMENT OF ALCOGAS RESEARCH IN THE PHILLIPINES *

by

Efren M.Sunico**

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** Senior Development Engineer, Nonconventional Energy Resources Division, Bureau of Energy Development, Philippines

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INTRODUCTION

The utilization of motor gasoline to power automobiles has been universally accepted for several decades. From the early years of development of motor vehicles, cars manufactured have favored the use of gasoline as fuel, specificallly because of its ready availability, suitability, and economical price.

However, with the advent of the OPEC embargo in 1973, came structural changes in market availability of oil and consequent increases in oil prices. This fuel crisis has dramatically pushed scientific endeavor in the search for alternative sources of fuel.

Shortage of petroleum fuels have frequently worked to reorient policies and attention to the utilization and production of alternate synthetic fuels, especially alcohol. In the early 1920's for instance, there was considerable concern over the imminent shortage of petroleum, and intense research on and discussion over the use of alcohol ensued. Numerous other occassions have arisen where shortages of petroleum have existed from political, economic or geographic reasons, and alcohol (ethanol) has always emerged as a technically viable alternative.

Inasmuch as alcohol is considered the most feasible and promising alternative fuel, the Philippines being a sugar producing country has good potential in embarking on a program for utilizing alcohol as motor fuel.

EARLY STUDIES AND RESEARCHES ON ALCOHOL AS MOTOR FUEL

The use of alcohol as motor fuel substitute or as blending agent for gasoline is not new in the Philippines. The earliest systematic work done in alcohol research was made in 1931 by A. L. Teodoro at the College of Agriculture, University of the Philippines (U.P.). Teodoro conducted extensive studies on straight alcohol, dehydrated alcohol blends with gasoline, blends with kerosene and with fuel oil.[1] The findings of Teodoro showed that automobile and tractors fueled by straight alcohol can be started without difficulty. With proper carburetor adjustment and ignition timing, acceleration is greater after the engine is warmed up. In general, engines run on alcohol were characterized by smooth running, steady pull, and absence of over heating, knocking and corrosion. However, the consumption of fuel per brake horsepower was greater with alcohol than with gasoline.

In January 1975, a research study made by the National Science Development Board (NSDB) had shown that cars require a special "sleeve"

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[1] Felix D. Maramba, Sr., Straight Alcohol as Motor Fuel, National Research Council of the Philippines Publications, 1978.

to be installed in the carburetor system if these were to be run by alcohol.[2] The findings claimed that ordinary carburetors cannot use alcohol because the thin jets (main and high speed inlet) are too small to admit a larger flow of alcohol needed. To avoid carburetor modifications and adjustments, alcohol must be blended with gasoline in tolerable amounts, before it could be used as suitable fuel.

BUREAU OF ENERGY DEVELOPMENT - PHILIPPINE NATIONAL OIL COMPANY ALCOGAS PROJECT

In December 1976, the Philippines embarked on an Alcogas Test Program in compliance with President Marcos' directive to study the possibility of utilizing ethyl alcohol as fuel substitute. This move was in accordance with an earlier mandate to accelerate the production of indigenous energy resources and create new markets for the country's surplus sugar production.

The Alcogas Test Program involved voluntary participation of 360 vehicles from the Philippine National Oil Company (PNOC), Bureau of Posts, Metro Manila Transit Corporation, Philippine Army, Caltex Philippines, Filipinas Shell, Delta Motors, and Chrysler Philippines. A mixture of 15% hydrous ethanol (190 proof) and 85% premium gasoline

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[2] Construction and Development Corporation of the Philippines (CDCP), A Study on Alcohol as Motor Fuel, CDCP Publications, 1977.

called "Hydrous Alcogas", was used on the participating fleet of vehicles. In contrast, t sts were also undertake., using a mixture . f 15% anhydrous ethanol of 99.5% minimum and 85% specially blended premium gasoline. This new mixture was named "Alcogas 99".

Miscibility of Alcohol Blends

The fundamental 85/15 alcogas formula was established on the basis of miscibility studies done on the actual materials utilized for the project. The miscibility curve of alcohol and premium gasoline shown in Figure 1 shows that an immiscibility of non-compatibility region existed up to 14.5% by volume of alcohol. Clear and homogenous blends result at 15% and beyond.

With respect to the miscibility characteristics of regular gasoline, complete miscibility is attainable at 20% volume and higher. This shows that the hydrocarbon compos'tion of the gasol'ne is the limiting factor for obtaining a homogenous hydrous ethanol-gasoline blend.

Results of the blending studies of anhydrous alcohol with both regular and premium gasoline confirmed that irrespective of hydrocarbon compositions, a homogenous alcohol-gasoline blend is readily obtainable when the alcohol component is practically dry.

Water Tolerance of Alcohol Blends

Anhydrous alcohol and gasoline are miscible in all proportions over a wide range of temperatures. However, even small addition of water to this blend fuel will cause separation of the alcohol from gasoline. The beginning of this separation is characterized by a cloudiness of the mixture.

With respect to the water tolerance of a 15/85 anhydrous ethanol gasoline mix, the amount of moisture that could initially induce cloudiness and subsequent phase separation in the mixture amounts to 0.9%. On the other hand, the 15% hydrous ethanol premium gasoline mix can readily be induced at 0.1% moisture addition.

Effects of Temperature on Alcohol Blends

Studies on the effects of temperature on alcohol blends was deemed necessary in order to investigate whether vehicles fueled by Alcogas 99 could efficiently operate in low temperatures such as that of Baguio.[3]

Hydrous alcogas was observed to have an irreversible alcohol phase separation at 60°F and lower. However, at 61 to 70°F, no signifi-

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[3] Summer capital city of the Philippines with an elevation of 1,500 meters above sea level where temperatures drop to about 10°C at certain times of the year.

cant phase separation was evident. On the other hand, gasoline blended with anhydrous alcohol was observed to be clear and homogenous even at temperatures substantially lower than 60°F.

Corrosion Effects on Alcohol Blends

In a laboratory type test procedure conducted by R.S. Bernardo of the Philippine National Oil Company essentially following ASTM D130 for Copper Strip Corrosion, hydrous alcogas was observed to have corrosion effects on ferro-magnetic materials, zinc, and zinc alloys. The results of the metal test on hydrous alcogas corrosiveness are shown in Table 1. Evaluations made on the corrosive property of Alcogas 99 showed that no significant effect has been observed in the tested metals. Table 2 shows the results of this test.

Evaluations made on the effects of hydrous alcogas on engine fuel systems showed that 18% of the participating cars had engine stalling complaints from systems clogging due to corrosion debris. Investigations on the nature of the materials found clogging fuel system components revealed three general types of particulate contaminants carried with fuel streams. The first type consisted of very fine rust particles which originated from internal surfaces of fuel tanks; the second type consisted of very fine gray to grayish-brown powdery materials eroded from zinc lines or galvanized fuel tanks and from zinc alloy components such as filter bodies and carburetors and third type consisted of debris from adhesive or sealants of fuel filters. These contaminants, being particulate in its structure, have blocking actions in the narrow orifices of fuel system components which consequently resulted in engine stalls and other difficulties in operating the engines.

Engine Performance Alcohol Blends

Although hydrous alcogas was acceptable to some vehicles, problems of vapor lock, hard starts, loss of power, higher fuel consumption, hesitation, surging fuel separation and engine stalling were reported by more than 50% of the test participants.

Vapor lock occurs when a disproportionate increase in vapor pressure and a depression of boiling temperatures of the mixture results from the molecular interactions of hydrous ethanol and gasoline.

Hard "cold starts" with hydrous alcogas were the results of high latent heat of alcohol-gasoline vapor mixture being poorly vaporized with the intake air in the carbureting process. Under this condition, only a limited portion of the volatilized fuel could provide an ignitable mixture at the spark plugs to start the cold engine. Hard "hot starts" were more apparent in the engine units where vapor locking effects predominated during a heat soak period when engines were stopped after prolonged operation.

Since Alcogas 99 has a lower heat energy content (Ⓐ19,085Btu/lb) than premium gasoline (Ⓐ20,250 Btu/lb), the net effect would be a leaner fuel-air mixture. Engines that were run by Alcogas 99 behaved as if the carburetors were adjusted to deliver less fuel and thereby resulted in low power outputs and higher fuel consumption.

Driveability problems related to surging and hesitation were traceable to acceleration vapor lock caused by unbalanced volatility properties of hydrous alcogas. Adjustment to richer carburetor settings had solved this difficulty in most vehicle units.

Table 3 shows the summary of engine performance and other related driveability problems resulting from the use of hydrous alcogas on cars.

In order to fully assess and evaluate the effects of anhydrous alcogas on engine performance, an Alcogas 99 Test Caravan from Makati to Baguio and vice versa,was undertaken in January 1978 (500 kilometer run). On the average, Caravan participants rated the performance of "Alcogas 99" highly satisfactory in all driveability characteristics evaluated ing the run, ranging from "hot" and "cold" startability to idling, acceleration, and cruising characteristics through power delivery and overall performance under the following Baguio conditions:

Temperature range:	56°F - 70°F
Barometric pressure:	25.1 in Hg
Altitude:	1,500 meters above sea level

The summarized joint rating of the caravan participants on the vehicle performance test is shown in Table 4. In the light of these results, the performance of "Alcogas 99" as an acceptable and efficient power fuel was clearly demonstrated. The test run similarly proved that anhydrous alcohol combined with the right gasoline hydrocarbon mix in a fully tested formulation could overcome vapor-lock and other volatility associated difficulties such as engine stalls and hard starts. In the overall context of the test-run, no Alcogas 99-related difficulty whatsoever was encountered throughout the entire run.

PROSPECT OF ALCOGAS AS NATIONWIDE MOTOR FUEL

A review and assessment of the Alcogas Project indicates that for best long-term results, anhydrous alcohol must be used in an alcohol-gasoline blending program.

Considering that alcohol shall have an important role during the implementation of the Alcogas program, the alcohol industry output is therefore taken into account. There are at present 19 distilleries (See Table 5) located in various parts of the country where sugarcane is grown in large quantities. They are equipped to produce 189 proof (94.5% by volume) alcohol and have a combined total production capacity of 421,770 liters alcohol per day, or 126.5 million liters per year, based on 300 operating days per year. Of the 50 million liters average annual production of alcohol, only half of the total capacity is presently being utilized.

Alcohol production comes almost exclusively from molasses because this appears to be the cheapest raw material. At present, the absolute alcohol yield per ton of molasses ranges from 275 to 300 liters. The average annual production of molasses is about 160 million gallons (Philippine Sugar Institute figure). Of the total volume produced, about 30-40% is domestically consumed while the balance is exported.

Even if the total annual production of molasses were utilized solely to produce alcohol, the same would still be insufficient to service total alcohol requirement of the program. Considering further that trade protection will have to be extended to domestic industries, then it is likely that only the exportable portion of molasses production could be available for an alcohol blending program. Consequently, implementation of the program would require the multiple expansion of capacities of existing distilleries.

The excess (export) molasses totalling approximately 112 million gallons per year could be converted into 162 million liters of anhydrous alcohol, which in turn is capable of substituting 6.5% of the country's annual gasoline consumption of 2.5 billion liters (See Table 6). This assumes an average distillery yield of 1.45 liters anhydrous alcohol that can be produced per gallon of molasses.

Considering that the alcohol blending program calls for the displacement of 15% of annual gasoline consumption by alcohol, then it becomes evident that alcohol production would have to be provided by sources other than molasses. It would thus appear necessary to convert sugarcane to alcohol to provide the deficit. As a consequence, more land should be planted with sugarcane so that extra harvest could be used for fuel alcohol production.

Although alcohol as motor fuel is technically feasible and acceptable, economic considerations show that alcohol blends at present, cost more than gasoline on a per liter basis. Comparing the selling price of premium gasoline at ₱1.81 per liter (1978 figure) and the production cost of anhydrous alcohol at ₱2.02 per liter (PNOC figure), it can be noted that a big discrepancy really exists. If fuel alcohol were to be competitively priced, a subsidy from the government may be required assuming that an alcohol-gasoline blending program is implemented.

THE SOCIO-ECONOMIC EFFECT OF ALCOGAS

In the overall context, except for few public acceptance problems that may arise in the introduction of Alcogas utilization, the alcohol-gasoline blending program does not seem to have any adverse effects. In contrast, the socio-economic benefits are as follows:

Development of Indigenous and Renewable Energy Resources

Alcohol has an advantage over gasoline because it can be produced from indigenous and renewable sources such as sugarcane, cassava and other crops containing high percentage of starch. With the use of alcohol as fuel, there would be lesser dependence on oil-based products.

Foreign Exchange

The key to the full justification on the use of alcohol blend as fuel lies in the serious need of the country for adequate dollar supply. But since alcohol at present costs more than gasoline, the advantage in foreign exchange savings must not be overcome by the disadvantage in the extra cost of fuel which might trigger inflationary movements.

The Alcogas program if implemented, has two main effects on the country's foreign trade. Firstly, it would bring about foreign exchange savings as lesser oil imports will be required in view of gasoline displacement achieved from the use of alcohol as motor fuel. At the same time, holding sugarcane and molasses for the alcohol-gasoline blending program entails a corresponding foreign exchange loss resulting from non-exportation of these commodities. If the price of sugar in the world market is low, a level may be reached where the second effect would be less than the first thus realizing net foreign exchange savings.

Reduction of Pollutants Emitted From Vehicles

The Alcogas blend is as environmentally acceptable fuel as compared to conventional gasoline, in view of of the reduction or even total elimination of tetra ethyl lead requirements (a toxic compound) and reduced unburned hydrocarbons in exhaust effluents.

Land Development and Employment Opportunities

The construction of new distilleries and the modernization and expansion of existing ones offers the opportunity for substantial development of land for growing of sugarcane and cassava as a supplemental fermentable crop and for wide employment both in the agricultural and manufacturing areas. With the creation of new job opportunities, regional development can be encouraged and accelerated.

Increase Technological Capabilities

Technological capabilities can be increased through acquisition and development of additional technical knowledge in alcohol production, sugar by-products utilization, alcohol utilization as fuel and feed stock for the agro-chemical industries, and improvement in sugarcane production. In the long run, there would be a high prospect of developing a new chemical industry based on alcohol rather then on oil.

Economic Boost to the Sugar Industry

Sugar is one of the country's leading dollar earner accounting for about one-fourth of the country's total foreign exchange receipts. However, the dollar-earning potential has been recently threatened by:

a. Depressed sugar prices in the world market as a result of over supply and competition from other sugar producing countries; and

b. Competition from high fructose corn syrup (HFCS), production of which is currently being accelerated in tha United States.

It is, therefore, necessary that the sugar industry should diversify its market for which alcohol offers high economic potential. A dual sugar-and-alcohol market will allow the sugar industry sufficient economic flexibility and serva as buffer in fluctuations in world sugar pricing. It facilitates control of sugar or alcohol production depending on the prevailing market situation.

MISCIBILITY CHARACTERISTICS OF RECTIFIED ALCOHOL (190 PROOF)

WITH PREMIUM GASOLINE @ 77°F

(R. S. Bernardo Data)

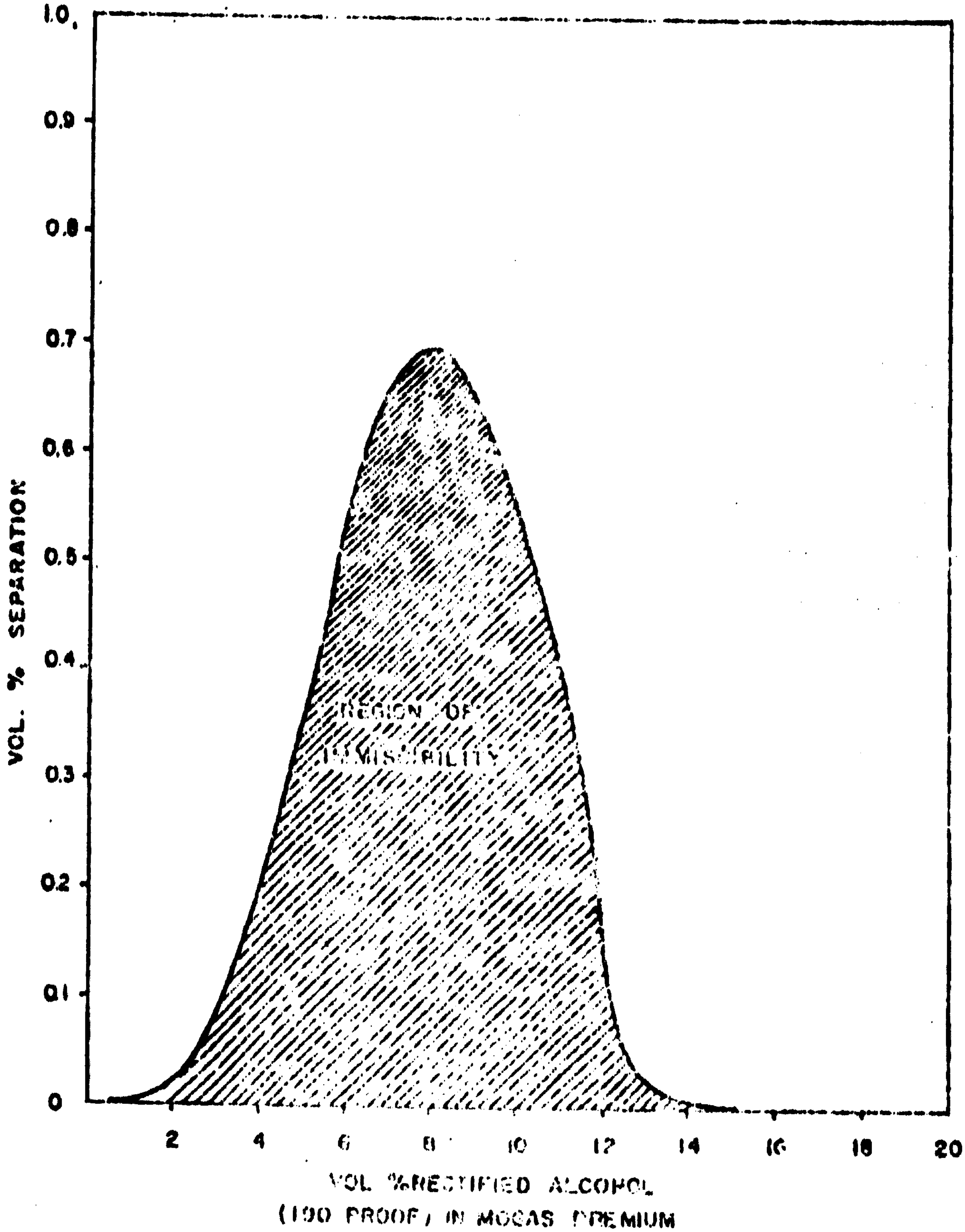

FIG. 1

TABLE 1

CORROSIVITY OF HYDROUS ALCOGAS TO METALS

@ 122°F (MODIFIED ASTM D130)

TYPE METAL	3 HRS	72 HRS
TINNED IRON (ASTM K081)	-	+
ALUMINUM (ASTM 329)	-	-
BRASS (ASTM B103)	-	-
CAST IRON (ASTM K076)	-	+
STEEL (ASTM A108)	-	+
ZINC (GRADE AR)	-	+
COPPER (99.9%)	-	+

(-) = NEGATIVE (NO TARNISH)

(+) = POSITIVE (TARNISHED & CORRODED)

Source: R. S. Bernardo, Philippine National Oil Company (PNOC)

TABLE 2

CORROSIVITY OF ANHYDROUS ALCOGAS TO METALS
@ 122°F (MODIFIED ASTM D130)

TYPE METAL	3 HRS	72 HRS
TINNED IRON (ASTM K081)	-	-
ALUMINUM (ASTM 329)	-	-
BRASS (ASTM B103)	-	-
CAST IRON (ASTM K076)	-	-
STELL (ASTM A108)	-	-
ZINC (GRADE AR)	-	-
COPPER (99.9%)	-	-

(-) = NEGATIVE (NO TARNISH)

(+) = POSITIVE (TARNISHED/CORRODED)

Source: R. S. Bernardo, Philippine National Oil Company (PNOC)

TABLE 3

SUMMARY - FUEL PERFORMANCE & OTHER RELATED DRIVEABILITY COMPLAINTS

NATURE	NO./FREQUENCY	% OF TOTAL
1. CORROSION/RUSTING OF FUEL SYSTEM	19	10.3
2. SYSTEMS CLOGGING WITH STALLING	64	34.6
3. VAPOR LOCKING (WITH & W/O STALLING)	29	15.7
4. FUEL LAYERING	38	20.5
5. HESITATION, SURGING	23	12.4
6. MATERIAL INCOMPATIBILITY	12	6.5
TOTAL	185	100.00

TABLE 4

VEHICLE PERFORMANCE RATING SUMMARY SHEET OF THE "ALCOGAS 99" TEST CARAVAN TO BAGUIO AND BACK JANUARY 28-29, 1978

TEST VEHICLE #	BRAND, TYPE & MAKE	A	B	C	D	E	F	G	H
			PERFORMANCE RATINGS AND DRIVEABILITY CHARACTERISTICS						
1.	CHRYSLER GALANT GS	1	1	1	1	1	1	1	1
2.	FORD ESCORT 1300	2	2	2	2	2	2	2	2
3.	FORD CORTINA 2000 E	2	1	2	2	2	2	2	2
4.	GM HOLDEN 1900 PREMIER	2	1	2	2	2	2	2	2
5.	GM GEMINI SL	1	1	1	1	1	1	1	1
6.	TOYOTA COROLLA DE LUXE	1	1	1	1	1	1	1	1
7.	TOYOTA CORONA SEDAN	2	2	2	2	2	2	2	2
8.	TOYOTA TAMARAW KF 10	1	1	2	2	2	1	2	1
9.	CHRYSLER COLT CELESTE	2	1	2	2	1	1	2	1
10.	CHRYSLER GALANT SIGMA SALOON	2	2	1	1	1	1	1	1
11.	CHRYSLER GALANT DE LUXE	1	1	1	1	1	1	1	1
12.	CHRYSLER LANCER 1400	2	2	2	2	2	2	2	2
13.	CHRYSLER CIMARRON	2	2	2	2	2	2	2	2
14.	DMG VW BEETLE 1500	2	2	2	2	2	2	2	2
15.	DMG VW BRASILIA	1	2	1	1	2	1	1	2
	TOTAL POINTS.	24	22	24	24	24	22	24	23
	AVERAGE RATING. . . .	1 6	1.47	1.6	1.6	1.6	1.47	1.6	1.53

LEGEND: I. PERFORMANCE RATINGS:

1 - EXCELLENT
2 - SATISFACTORY
3 - BORDERLINE
4 - NEEDS IMPROVEMENT
5 - UNACCEPTABLE

II. DRIVEABILITY CHARACTERISTICS:

A - "HOT" STARTABILITY
B - "COLD" STARTABILITY
C - LOWLAND IDLING
D - UPLAND IDLING
E - ACCELERATION
F - CRUISING
G - POWER DELIVERY/ CLIMBING ABILITY
H - OVERALL RATING UNDER BAGUIO CONDITIONS

TABLE 5

LIST OF ALCOHOL DISTILLERIES
WITH THEIR ADDRESSES & CAPACITIES

LUZON	LOCATION	Capacity (liters/day)
1. Mind Sugar Central	Manaoag, Pangasinan	6,000
2. Paniqui Sugar Central	Paniqui, Tarlac	10,570
3. Tarlac Distillery Corp.	San Miguel, Tarlac	40,000
4. Integrated Sugar Co.	Del Carmen, Pampanga	17,000
5. Superior Alcohol Ind. Co.	Apalit, Pampanga	12,500
6. Republic Alcohol Dis.	Calumpit, Pampanga	20,000
7. Tecson Chemical Corp.	Balagtas, Bulacan	30,000
8. Berbacs Chemical Corp.	San Pedro, Laguna	22,000
9. Canlubang Sugar Estate	Canlubang, Laguna	15,000
10. Central Azucarera, Don Pedro	Nasugbu, Batangas	35,000
	Sub-Total	208,070

NEGROS		
1. Victorias Milling Co.	Manapla, Negros Occ.	47,200
2. Talisay-Silay Milling Co.	Talisay, Negros Occ.	26,000
3. Kool Company, Inc.	Talisay, Negros Occ.	10,000
4. Central Azucarera de la Carlota	La Carlota, Negros Occ.	22,500
5. Binalbagan-Isabela Sugar Co.	Binalbagan, Negros Occ.	30,000
6. Asian Alcohol Corp.	Pulupandan, Negros Occ.	30,000
	Sub-Total	165,700

ILOILO		
1. Central Santos-Lopez Co., Inc.	Barotac Nuevo, Iloilo	8,000

CEBU		
1. Asian Alcohol Corp.	Consolacion, Cebu	30,000
2. Cebu Alcohol Plant	Mandawe, Cebu	10,000
	Sub-Total	40,000
	T O T A L	421,770

Source: Philippine Sugar Institute's Industrial Research and Development Office

TABLE 6

GASOLINE CONSUMPTION: 1970-1978
(IN MILLION LITERS)

YEAR	REGULAR	PREMIUM	TOTAL CONSUMPTION
1970	1,811	580	2,391
1971	1,920	598	2,518
1972	1,908	611	2,519
1973	1,954	663	2,617
1974	1,659	664	2,323
1975	1,611	814	2,425
1976	1,473	879	2,352
1977	1,397	970	2,367
1978	1,332	1,063	2,397

Source: Philippine National Oil Company (PNOC)

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B - 82

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