

PERFORMANCE EVALUATION OF REFINERY PRODUCTS

(A CASE STUDY OF PREMIUM MOTOR SPIRIT)

BY

ABOLARIN ABDULGANIYU

MATRIC NO. 98/6798EH

**DEPARTMENT OF CHEMICAL ENGINEERING, SCHOOL OF
ENGINEERING AND ENGINEERING TECHNOLOGY,
FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA,
NIGER STATE, NIGERIA.**

NOVEMBER, 2004

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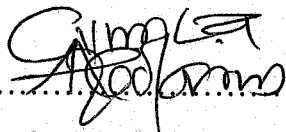
MATRIC NO. 98/6798EH

**A RESEARCH PROJECT SUBMITTED IN PARTIAL
FULFILLMENT OF THE REQUIREMENT FOR THE AWARD OF
THE BACHELOR OF ENGINEERING (B. ENG) IN CHEMICAL
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MINNA, NIGER STATE, NIGERIA.**

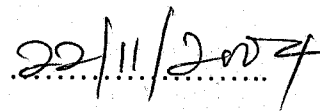
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DECLARATION

I, Abolarin Abdulganiyu (98/6798EH) declare that I carried out this project work presented in this report in accordance with the regulation governing the preparation and presentation of project in the Department of Chemical Engineering, Federal University of Technology, Minna.



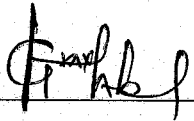
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CERTIFICATION

I certify that, this project titled "Performance evaluation of refinery products" has been supervised, read and approved as meeting the requirements of the Department of Chemical Engineering, School of Engineering and Engineering Technology, Federal University of Technology, Minna, for the Award of the Bachelor of Engineering degree.



Engr. A.G. Isah
Project Supervisor



Date

Dr.F.O. Aberuagba
Head of Department

Date

External Examiner

Date

DEDICATION

To the Almighty Allah who is the beginner, middle and end of everything, I dedicate this project to.

Also to my ever present parents; Abolarin O. Badmus and Hajia Abolarin A. Falilat.

ACKNOWLEDGEMENT

All praises are due to Almighty Allah for sparing my life throughout my academic pursuit and for everything he has bestowed on me.

My deep appreciation goes to my project supervisor, Engr. A.G. Isah for his encouragement, time, understanding and energy committed in reading this project work.

My profound gratitude goes to my parents; Abolarin O. Badmus and Hajia Abolarin A. Falilat. I can't thank you enough for all you have done for me. May you live long to reap the fruit of your labour (Amin).

If there is anything that really do make me happy; it is love and understanding I do gain from my family, my elder brothers; Abolarin Abdulrazaq, Abolarin Abdulazeez, my younger brothers and sisters; Abolarin Tejumola, Abolarin Wasiu, Abolarin Hammed, Abolarin Saheed, Abolarin Kamlat, Abolarin Fatimoh, Abolarin Mukaila, Abolarin Muideen and others, I acknowledge you all.

Special thank goes to Sharifat Shola Olajide Abdulsalam whose level of understanding, care, love and tenderness always challenge me. May Allah let us live long for each other.

I appreciate the love, care and understanding I do gain from my friends, Owokunle Azeez, Owokunle Lawal, Obanimomo Taiwo, Sheu Akeem, Lukman Lawal, Afolayan Segun, Ali Balogun Suleiman, Ezzie O. Keneth Fayomi Ayodeji, Akolade Kazeem, Ibrahim Tolani, Akano A. Hafiz and others whose their names cannot be mentioned.

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Without NNPC Ilorin staff, this project would not have been succeeded; therefore I use this medium to thank Mr O.O T. Iji, the laboratory technician and other staff for their help and ~~other~~ understanding.

Also, to all my people that their name can not be mentioned, I thank you all.

Finally, I thank Almighty Allah again for his almightiness in my life.

ABSTRACT

This project work carried out the performance evaluation of refinery products using premium motor spirit as case study. The sample collected from NNPC and four other Filling Stations (TOTAL, MOBIL, TEXACO and CONOIL) in Ilorin were used for the evaluation. Standard analysis was carried out on the products and the results of the experiments were compared with the NNPC standard specifications. The results showed that properties of the products were within specifications which implied that products are not adulterated.

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ABBREVIATION

R.V.P	=	Reid vapour pressure
R.O.N	=	Research octane number
A.S.S.	=	Active sulphur species
ASTM	=	American society for testing and materials
IP	=	Institute of petroleum, London
API	=	American petroleum institute
IBP	=	Initial boiling point
FBP	=	Final boiling point
PMS	=	Premium motor spirit
HC	=	Hydrocarbon
D.P.K	=	Dual Purpose Kerosene
A.G.O	=	Automobile Gas Oil

CHAPTER ONE

1.0 INTRODUCTION

When products are contaminated, take for instance premium motor spirit which is the case study in this project, the distillation quality, viscosity, combustion and other characteristics of the product will change which in turn affect the performance of the product. Similarly, DPK which is a petroleum product used by every home for domestic purpose, if contaminated can lead to excessive burning as a result of reducing its flashing point by contamination with PMS. A typical encountered of DPK contamination that caught fire happened in Kunlade area in Ilorin in year 2003 when a tanker driver carelessly loaded DPK into a PMS off-loaded tanker without cleaning or washing of the tanker. This particular effect led to the burning of many houses which might have been prevented if the property of the products was ascertain before it was sold out to consumers.

This product adulteration, which is deliberately or sometimes accidentally done, is to achieve quantity increase at the expense of the product quality by the perpetrators, which consequently contaminate the products. Therefore, work of this nature is necessary to be carried from time to time by independent body, to avert the problem caused by product adulteration.

1.1 Origin of petroleum

The word 'petroleum' comes from the Latin Petra ('Rock') and oleum ('oil') (Nelson, 1984). The rock in which the petroleum is found lies deep underground. This petroleum is called crude oil by people in the oil industry. Crude oil is a liquid and is made up of mixture of various compounds comprising carbon and hydrogen, otherwise referred to as hydrocarbon, sulphur, oxygen and also nitrogen compounds which present in small amount. Crude oil varies greatly in appearance and this

difference in appearance of crude oil is caused by the location of crude (Nelson, 1984). Therefore, crude oil varies greatly in thickness, colour and odour. Some are black and thick; others are yellow and bright while some are light yellow or dark brown.

There are two theories to explain the origin of oil. They are the inorganic and organic theories. The inorganic theories holds that hydrogen and carbon were brought together under great pressure and temperature deep in the earth to form oil and gas, which then found its way through porous rock to collect in natural traps in the underground formation of the earth (Ronald et al, 1981).

The organic theory presumes that both the hydrogen and carbon that make up petroleum came from plant and animal living on the land and in the sea. The organic theory is the explanation most generally accepted by scientists. The arguments for the theory is found in the evidence left in the underground rock by ancient sea which through great period of time have covered much of the present land area. The Gulf of Mexico, for example, is a part of one of these old seas. Throughout millions of years, rivers flow down to these seas and carried with them great volumes of mud and sand to be spread out by currents and tides over the sea bottoms near the gradually changing shores lines.

Each day through thousand of years new deposits were distributed layer upon layer over the sea floors. Under the increasing weight of accumulating new bed, the ocean floors slowly sank, so that they were built up the thick series of mud and sand layers. These sea bottoms mud, and sand were squeezed by the lying layers of mud and sands and eventually became what are called sedimentary rocks, the sand stones, shale, the limestone and dolomites.

Also, more sediment was covering the oil sea floor. Heat and pressure change

mud and clays deposited earlier into layers of porous sand stone and limestone. These rocks are called sedimentary because they were formed from sediments. In time, tiny droplets of oil, seeped into layers of these porous rocks and were held in almost the same way that a sponge holds water.

Generally, oil droplets became concentrated, in places where a non-porous rock layers, though which they could not pass, blocked their movement. Since the origin of petroleum was accepted, the search for oil is confined to areas underlain by thick sections of sedimentary rocks, for it was in these rock that the source animals, plants and marine remains were buried. The crude oil is reached by drilling beneath the earth's surface.

1.2 Introduction of Pms (Gasoline)

Premium motor spirit (gasoline) is a volatile, flammable liquid product obtained through the processing of petroleum with the boiling ranges of 30-210°C. Gasoline is a mixture of light liquid hydrocarbons. (Anonymous, 1993).

The hydrocarbons found in gasoline are within the ranges of C₄ – C₁₂ and the predominant class is the paraffin, 150 paraffin, and cycloparaffins of naphthones as well as aromatic hydrocarbon. Most gasoline is used as fuel for internal combustion engine that power automobiles, motorcycles, motorboats and other equipment's.

Gasoline is of two kinds i.e. automotive (motor) gasoline and aviation gasoline. Automotive gasoline may be leaded or unleaded and is usually sold in two grades, commonly called regular and premium. The main difference between these two grades is that premium has a higher octane number than regular, though in addition premium may contain more

additives (gasoline contains small amount of chemical called additives that improved performance). The higher the octane number the greater is gasoline's ability to avoid creating knock.

Engine knock, hard as a knocking or paging sound occurs when the air gasoline mixture in the combustion chamber of an engine burns unevenly. Engine knock decreases the power of the engine, and in extreme cases can damage the engine completely.

1.3 Physiochemical properties of Pms (Gasoline)

1.3.1. Volatility

The volatility of a motor gasoline is the measure of how the gasoline can easily be vaporized. This volatility of gasoline affects the performance of the engine in numbers of ways. The ease of starting, rate of warm up and adequate vaporization for proper distribution between the cylinder (i.e. acceleration). The volatility of gasoline is normally determined by the ASTM distillation test.

1.3.2 Combustion characteristics

Under normal conditions, the flame initiated as sparking plug spreads evenly across the combustion space until the gasoline has been burned. The combustion characteristic of gasoline is a measure of its octane number and is determined by research octane rating (RON).

1.3.3. Stability

Motor gasoline when stored for months or even longer before used, it should not undergo any deformation, and should remain stable (i.e.

unchanged) on storage, gasoline came in contact with air and also subjected to the effects of heat. An unstable gasoline will undergo oxidation and polymerization under such condition forms gum. Gum formation may eventually form a chain reaction. Stability of gasoline is determined in the laboratory by existent of gum test.

1.3.4. Corrosion

Gasoline must be free from corrosive compounds both before and after combustion. Corrosiveness is primarily due to the presence of free sulphide and sulphurdioxide. This combine with water vapour formed by the combustion of the fuel to produce sulphuric acid which may later oxidized to a lesser extent sulphuric acid. Both acid are corrosive towards iron and steel and would attack the cooler parts of the engine exhaust system and its cylinder. The corrosiveness of gasoline is determined by the total sulphur content test.

1.4 General Properties of fuel oil

1.4.1. Viscosity

Viscosity is a measure of the resistance flow offered by a fluid and therefore affects for example, the power required to pump the fuel through a supply pipe and success of atomization, (Anonymous, 1981). Viscosity is a temperature dependent, fuel oils becoming less viscous as their temperature rises, and the thus a knowledge of the viscosity temperature relationship provides a oil storage information and allows the

optimization of storage/pumping condition as well as atomizing conditions.

1.4.2. Specific gravity (relative density)

The specific gravity of a fuel oil has both direct and indirect value. Directly, it has the common significance of showing the mass per unit volume and therefore being used in determining storage and heating needs. Indirectly, particularly for petroleum oil fractions relationship between specific gravity and several other properties and demonstrable that can be used to predict fuel characteristics.

1.4.3 Flash point

Flash point is the lowest temperature, corrected to a pressure of mmHg (101.3 Kpa), of the sample at which application of an ignition source causes the vapour of the sample to ignite or explode under specified condition of text, (Anonymous, 1981).

1.4.4. Pour point

As fuel oil is not single compound but complex mixture, they do not have either a single melting point or boiling. Solidified oil when heated will melt progressively into liquid form and will become progressively inclined to flow as a liquid, this change both related to both chemical and physical properties of oil. This properties is of practical importance since, the viscosity, it controls the point ability of the fuel and the associated temperatures.

1.4.5. Combustion

The calorific value: since the primary aim of a fuel is to produce heat by combustion, the calorific value of a fuel is of fundamental importance when assessing the probable performance of a fuel and combustion system and for assessing overall thermal and economic efficiency.

Calorific value, ash content and carbon residue of a fuel oil determine its combustion characteristics.

1.4.6 Stability

A property of importance where storage or used delay is concerned. In general, the term means the retention of initial properties but in particular, it refers to the degree of formation of sludge or sediments from the oil substance itself.

1.5 Objective of the work

This research works aim are to evaluate the performance of premium motor spirit gasoline, through the measurement of the (gasoline), properties both physical and chemical properties. The results of the measurement (experiment) are then compared with the standard value.

1.6 The scope of the work

This project work, performance evaluation of refinery product covers the determination of some properties of gasoline and collection of past data on Pms from Ilorin PPMC depot and some filling stations at Ilorin. The results of experiments were compared with standard value.

1.7 Limitation of the project work

Limitations to some of the tests were due to the breakdown of the equipments needed to carry out the experiment. Those tests that cannot be carried out as a result of equipment breakdown include octane number research, existence of gum, but past results on such tests were within reach.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Preparation of petroleum for refining

Petroleum extracted from wells is purified from foreign matter before being delivered for processing. The gases dissolved in the crude petroleum, water, forming stable emulsions, mineral salts and many impurities such as sand and clay are removed from crude petroleum.

The accompanying gases are removed from the petroleum by lowering the pressure. The lightest petroleum hydrocarbons that are liberated are separated from the accompanying gases by absorption with absorbing oils or absorption by activated carbon. Water is removed by prolonged setting in special setting tanks. The impurities are separated simultaneously or by using different ways of destroying the stable emulsions e.g. by heating in the presence of emulsification agents usually sodium salts (Ronald and Edwin, 1981).

2.2 Petroleum refining process

Crude petroleum is put through much petroleum refining process in refinery to yield hundreds of oil products for daily use.

Petroleum processing method is divided into two groups: physical (primary) petroleum processing methods and chemical (secondary) petroleum processing methods.

2.3 Physical (primary) petroleum refining method

Physical petroleum processing methods are based on the use of differences in the physical properties of substances incorporated in the crude petroleum. Therefore, crude in which is a mixture of substances called hydrocarbon whose molecules are composed of atoms of carbon and hydrogen are separated into groups or fractions that are similar i.e. of similar molecular weight. Examples of physical refining methods are: fractional distillation, crystallization and solidification, solubility in solvents.

2.3.1 Fractional distillation

Fractional distillation makes use of the fact that petroleum products evaporate from it as temperature rises according to their volatilities. When petroleum is heated, the highest and most volatile hydrocarbons evaporate first and the heaviest and least evaporates last. If the vapour is then cooled, they condense back to liquid in the reverse order, the least volatile first and most volatile coil last, and this enables the mixture of hydrocarbons to be separated.

Fractional distillation is carried out in crude distillation unit (CDU) in the refinery. The column is a tall steel cylinder with a thermal insulating lining divided by horizontal plates. Plates (trays) have considerable number of openings for passage of the vapour with chimney over which caps are secured. Down comer ensures the flowing down of liquid fractions and are arranged along the periphery of the plate. The

petroleum is first passed through heat exchanger where it is heated to about 180°C, with the product flowing out of distillation column. The petroleum is further heated to between 320 & 350°C in the tabular furnace to form a vapour liquid mixture which is fed into the distillation column. Steam is fed to the bottom of the column in which the petroleum is separated into fractions or distillates which are removed consecutively along height of the column. Petrol vapour are removed from the top, cooled in cooler and condensed to liquids which is partially removed and partially used to spray the column. Petrol yield is about 3-15% of the petroleum fed. Other distillation products ligroin, kerosene, solar distillate and mazut are removed from the column, cooled in the heat exchangers and pumped to storage sites, (Ronald and Edwin, 1981).

2.4 Chemical (secondary) petroleum refining method

Chemical petroleum processing methods are based on the fact that the hydrocarbons in petroleum and petroleum products undergo chemical transformation under the effect of temperature, pressure and catalyst. If the refining of crude oil were confined simply to distillation or other physical separation process which after all the chemical composition of the original crude, the production of natural gasoline would be insufficient to provide the world's gasoline requirement and the octane rating would be inadequate. Therefore, products obtained directly from the CDU side stream which is known as straight run or virgin products or crude oils are undergo chemical refining processes to modify the nature of the

constituents in the crude oil. The chemical refining methods includes: cracking, hydrogenation, reduction, chlorinating, isomerization, reforming, alkylation, polymerization, sulphation, sulphonation, condensation, nitration dehydrogenation, hydrolysis, estrification and oxidation.

2.4.1 Cracking

This process involves the rapture of C-C and C-H bonds in the hydrocarbon chains producing intermediate radicals which then produce smaller paraffin and olefin molecules. In this way heavy fractions such as diesel fuel can be cracked to form lighter fraction such as gasoline. Cracking is carried out in a catalyst cracker. The three main cracking processes are: catalytic cracking, thermal cracking and hydro-cracking (Hobson, 1985).

2.4.1.1 Catalytic cracking

These are high temperature processes in the presence of catalysts. Catalyst cracking is carried out at between 450-500⁰C and at atmospheric pressure in the presence of a catalyst such as solid and porous bodies composed mainly of alumna (Al_2O_3) (i.e. the carrier). The petrol yield in this process is about 70% of the raid material weight. They produce petrol of high octane number (90-92 units). They also produce HC – containing gases of about 12-15% of the raid material weight.

The disadvantage of this catalytic cracking is that the catalyst becomes quickly unserviceable (lose activity). Therefore, catalytic cracking is done in the continuous-action catalytic reactors containing two parts; a reactor and a generator.

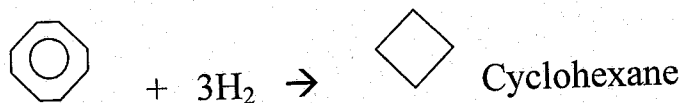
Moving bed catalytic cracking, which circulates the catalyst between the reactor and generator is a widely used apparatus for catalytic cracking.

The raw material will be heated in tubular furnace and fed to the top of reactor into which the regenerated catalyst is admitted from bin. The cracked product is removed from the top and separated. The used catalyst is taken from the catalytic reactor from the bottom and is admitted to generator. The regenerated catalyst is fed from the bottom of the generator through air lift by compressed air forced into bin? (Ronald and Edwin, 1981).

2.4.2 Hydrogenation

This is the process of adding hydrogen atom(s) to the double and triple bonds of unsaturated structures or a process of subjecting to chemical actions of or causing to combine with hydrogen (Bhaskira, 1990) e.g. ethylene hydrogenates to ethane $\text{CH}_2\text{CH}_2 + \text{H}_2 \rightarrow \text{C}_2\text{H}_6$,

Benzene to cyclohexane i.e. benzene + 3H_2

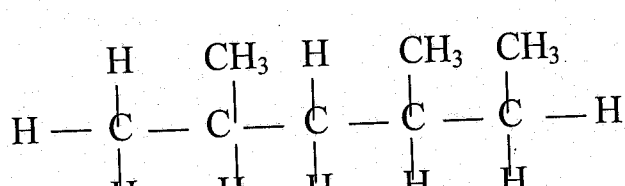
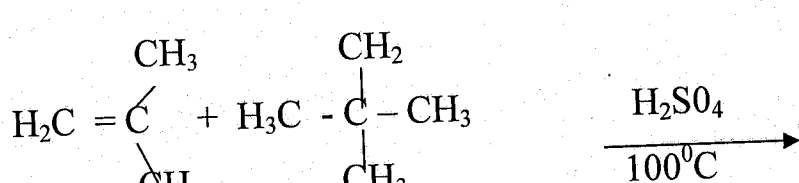


2.3.3 Alkylation

The word 'alkyl' signifies a building block which is made up of hydrogen and carbon atoms in the ratio given by the formula C_nH_{2n+1} . Example of the alkyl groups are methyl (CH_3), Ethyl C_2H_5 etc.

Alkylation in a general term means any reaction in which an alkyl group is added to a molecule, for instance, methylation is a specific term indicating the addition of a methyl group (CH_3) building block to a hydrocarbon which of course must lose a hydrogen atom to make way for the new alkyl group unless an unsaturated bond is broken.

Alkylation is a reverse of cracking; it joins an olefin with paraffin. For example, alkylation reactions are exothermic (Erikn and Redin, 1981).



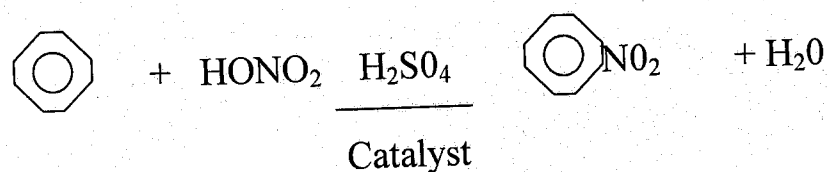
2.4.4 Nitration

This is the introduction of the nitro group, NO_2 into organic compound by the use of nitric acid. In the nitration reaction, usually one or more of the H atoms of the aromatic ring is replaced by a nitro group as a result of treatment of the aromatic compound with nitric acid using sulphuric acid as a catalyst. Nitration is used in the manufacture of dye

intermediates and dyes. It is important in the production of explosives.

Many nitro derivations of organic compound are chemically unstable.

The overall equation of the nitration process is given as follows:

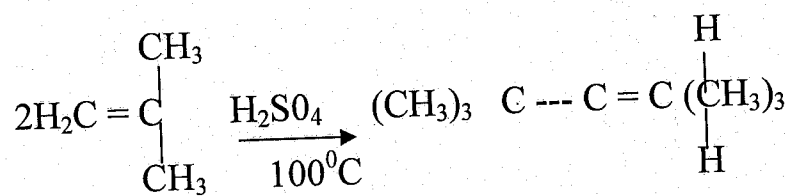


2.3.3 Isomerization

In this conversion process, straight chain alkanes are converted into branched chain isomers at about 110°C and under pressure in the presence of aluminum catalyst e.g.

2.4.6. Polymerization

Under this process, gaseous and low boiling point alkanes found in the gas fraction and occurring as by products if cracking process are polymerized (involving together of small molecules) in the presence of a catalyst. The polymer is still an unsaturated hydrocarbon but may be converted into an alkane by treatment with hydrogen e.g.



2.5. Important gasoline tests

2.5.1 Octane number

Octane number is a value used to indicate the resistance of a motor fuel to knock. Octane numbers are based on a scale on which isooctane is 100 (minimal knock) and heptane is 0 (bad knock).

A gasoline with an octane number of 92 has the same knock as a mixture of 92% isooctane and 8% of heptane.

The research octane number (RON) helps to determine the octane number of a fuel. The higher the RON, the better the performance. If the RON is too low, correction is made by blending with isooctane gasoline or adding an additive called tetraethyl lead (TEL) which has very high octane number to improve the octane number of the product.

2.5.2 Density and API gravity

Density (ρ) is the mass of a unit volume of material at a selected temperature. For example the density of water is 0.999 grams per cubic centimeter (g/cm^3) at 60°F (15-67°C). Relative density (RD) also called specific gravity is the ratio of the density of the material at a selected temperature to the density of a reference material at a selected temperature.

For the relative density of petroleum, the reference material is water and both temperatures are 60°F. API gravity is an arbitrary scale developed by the American petroleum institute in the early years of the

petroleum industry. API gravity measurements may be made on a liquid at temperature other value at 60⁰F (15⁰C), the standard temperature.

2.5.3 Reid vapour pressure

Vapour pressure is an indication of the pressure that a material will develop within a closed container and is particularly significant for a material whose boiling point are so low that they can not be distorted at atmospheric pressure without a serious loss. The test is important with respect to safety in transport, types of storage tanks employed and the starting characteristic of motor fuel. Vapour pressure is critically important for both automotive and aviation gasoline affecting starting warm-up and tendency to vapour lock with high operating temperature or high altitudes. Vapour pressure is an important physical property of volatile liquids; excessive vaporization will also result in loss of fuel from storage and vehicle tanks. (Anonymous, 1981).

2.5.4 ASTM fractional distillation

ASTM fractional distillation covers the distillation of natural gasoline, motor gasoline, kerosene gas oil, fuel oil. It specifies the evaporation characteristics (volatility) of gasoline. The thermometer reading that is observed at the instant that the first drop of condensate drops from the lower end of the condenser tube is called initial boiling point (IBP) while the final boiling point (FBP) is the maximum thermometer reading.

The temperature is recorded as each successive 10% condensate recovery is collected at intermediate temperature. Certain % of the distillate (recovery) has different function as related to gasoline engine for examples, ease of starting or warming up is governed by IBP – 10% range boiling point. Rate of accelerations follows after the starting operation which is best judged by the mid-region boiling range like 30-60%, while 90% - FBP is known as crown case dilution. At this point the gasoline will not be evaporating normally that is fuel is not volatile at the working condition of carburetor. Therefore, distillation is important to eradicate contamination determining the boiling range and the volatility of petroleum products.

2.5.5. Total sulphur content

Sulphur compounds are extremely harmful to gasoline. More tetraethyl lead (TEL) will be required to improve the octane number of gasoline if sulphur components are present.

The sulphur components in petroleum are first removed by passing crude oil through disulphuring unit in refinery. The test method is primarily carried out to detect the mercaptans in motor fuel, kerosene and similar petroleum products. Sulphur present as mercaptans or as hydrogen sulphide in distillate fuels and solvents can attack many metallic and non metallic in fuels and other distribution system (Nelson, 1984).

2.6 Important fuel oil test

2.6.1 Flash point

Flash point is the lowest temperature, corrected to a pressure of 760mmhg (101.3 kpa), of the sample at which application of an ignition source causes the vapour of the sample to ignite under specified conditions of test.

Flash point test serve to indicate temperature blow which oil can be handled without danger of fire. Flash point is used in shipping and safety regulations to define 'flammable' and combustible materials. It can indicate contamination of an oil sample by indicating the presence of highly volatile and flammable material in relatively nonvolatile or nonflammable. (Anonymous, 1981).

2.6.2 Pour point

Pour point is the lowest temperature expressed as a multiple of 5⁰F or 3⁰C at which the oil is observed to flow when cooled and examined under prescribed conditions.

The significance of this test is that it gives an idea of the characteristics flow of sample, the temperature at which the sample is pumpable and hence the plan for its transportation and it helps to determine the storage facilities of the sample (Anonymous, 1981).

2.6.3 Density and API gravity

Same as gasoline above.

2.6.4 Viscosity of fuel oil

The viscosity of oil is a measure of its resistance to internal flow and is an indication of its oiliness in the lubrication of surface.

2.6.5 Water and sediments in fuel oil

Water and sediments are impurities in fuel oil which indicate the moisture content of the sample and it has serious effect on engine.

The presence of water and sediment in fuel oil may cause serious problem such as:

- (a) Unstable combustion
- (b) Complete interruption of combustion
- (c) Back fire in motor engine
- (d) Plugging or blocking of the burner head and pipe
- (e) Heat loss
- (f) Erosion of mechanical parts and nozzle

The water and sediments contents are determined by centrifuge method. (Anonymous, 1981).

CHAPTER THREE

3.0 EXPERIMENTAL WORKS

The work is based on performance evaluation of refinery products using premium motor spirit (gasoline) as case study. Gasoline sample were collected from different five sources i.e. Total, Texaco, Mobil, Con oil and Ilorin PPMC laboratory. The analysis were carried out on these gasoline based on their properties at Ilorin PPMC laboratory. The results of analysis are provided in chapter four.

3.1 Standard test method for gasoline

3.1.1 Test for density

Hydrometer method

Apparatus:

Hydrometer, thermometer, hydrometer cylinder and constant temperature beets.

Procedure:

The sample was transferred into a clean hydrometer cylinder without splashing, in order to avoid the formation of air bubbles and to reduce to a minimum evaporation of the lower boiling constituents of more volatile samples. The air bubbles formed but not in all cases are removed after they are collected on the surface of the sample, by touching them with a piece of clean filter paper.

The cylinder containing the sample was placed in vertical position in a location free form air current. The hydrometer was then lowered gently into the sample and care was taken to avoid wetting the stem above

the immersion level. The sample was continuously stirred with a thermometer for at least thirty seconds before the thermometer reading was taken. After the hydrometer has come to rest, floating freely away from the walls of the cylinder, the hydrometer reading is taken from the scale on the stem of the hydrometer and recorded. This procedure was repeated for three more time on a particular sample and their average was taken as the thermometer and hydrometer readings.

3.1.2. Distillation of petroleum products

Apparatus:

A 100ml flask, condenser, cooling bath, shield, heater, flask support, graduated cylinder and thermometer.

Procedure:

100ml of sample was measured and transferred into distillation flask; the distillation flask was placed on heater. Heat was then applied to the distillation flask contents i.e. sample. The heating at the initial stage was regulated that the time interval between the first application of heat and the initial boiling point does not exceed the limit as prescribed in standard text book.

The initial boiling point and final boiling point, thermometer reading for 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90% and 95% recovery were also recorded. The percent total recovery was then calculated by adding the percent recovery and the percent residue. The percent total recovery was deducted from 100 to obtain the percent loss.

3.1.3 Reid vapour pressure test

Apparatus:

Reid vapour pressure apparatus consists of two chambers, a vapour chamber (upper section) and a liquid chamber (lower chamber).

Procedure

The sample was transferred into the liquid chamber by the use of transfer tube. Immediately the vapour chamber was removed from the water bath and coupled with the filled liquid chamber as quickly as possible without spillage and without undue movement that could promote exchange of room temperature air with the air in the chamber.

The assembled apparatus was then turned upside down to allow the entire sample in the liquid chamber to drain into the vapour chamber. With the apparatus still inverted, it was shaken vigorously for eight times up and down with the gauge end up. The apparatus was immersed in a bath maintained 100 of in an inclined position so that the connection of the liquid and vapour chamber is below the water level and carefully examine for leaks.

After the assembled apparatus has been in the water bath for at least 5 minutes, the pressure gauge was tapped slightly and the reading observed and the procedure repeated at intervals of not less of minutes for not less than 5 sticking and gauge reading have been made.

This procedure was continued as necessary until the least to consecutive gauge reading are the same indicating that equilibrium has been reached.

3.1.4 Test for sulphur content (Doctor Test)

This is a qualitative test for the presence of hydrogen sulphide (H_2S) and mercaptans in gasoline, jet fuel, kerosine, fuel oil and similar petroleum products.

Apparatus:

Rubber stopper, test – tube-25 x 150mm

Reagents

Distilled water, sulphur –pure; dry flower stored in a closed container.

Doctor solution – dissolve 125g of NAOA in litre of distilled water. Add 100g of lead monoxide (PbO) and shake vigorously for 15 minute and allow standing overnight.

Decant or siphon off the clean liquid. If the liquid does not settle clear, filter it using filter paper. Keep the solution in a tightly stopped bottle fitter again, if it becomes cloudy.

Procedure

Exactly 5ml of prepared doctor solution (sodium plumbite) was added with 10ml of the sample to the test tube. Shake vigorously for 15 seconds. Observation was made for any appearance of black or brown precipitates. If this occurs, sulphur is present.

In the absent of H_2S , the mixture was put in test tube and a small pinch of sulphur will just cover the interface between the hydrocarbon and doctor solution was added and shaken vigorously again for 15 seconds and allow to settle for 1 minute. If mercaptans are present, on shaking

they undergo a series of reactions, colouring the hydrocarbon layer first orange, then red and brown and finally a black precipitates appears.

3.1.5 Determination of corrosiveness of pms

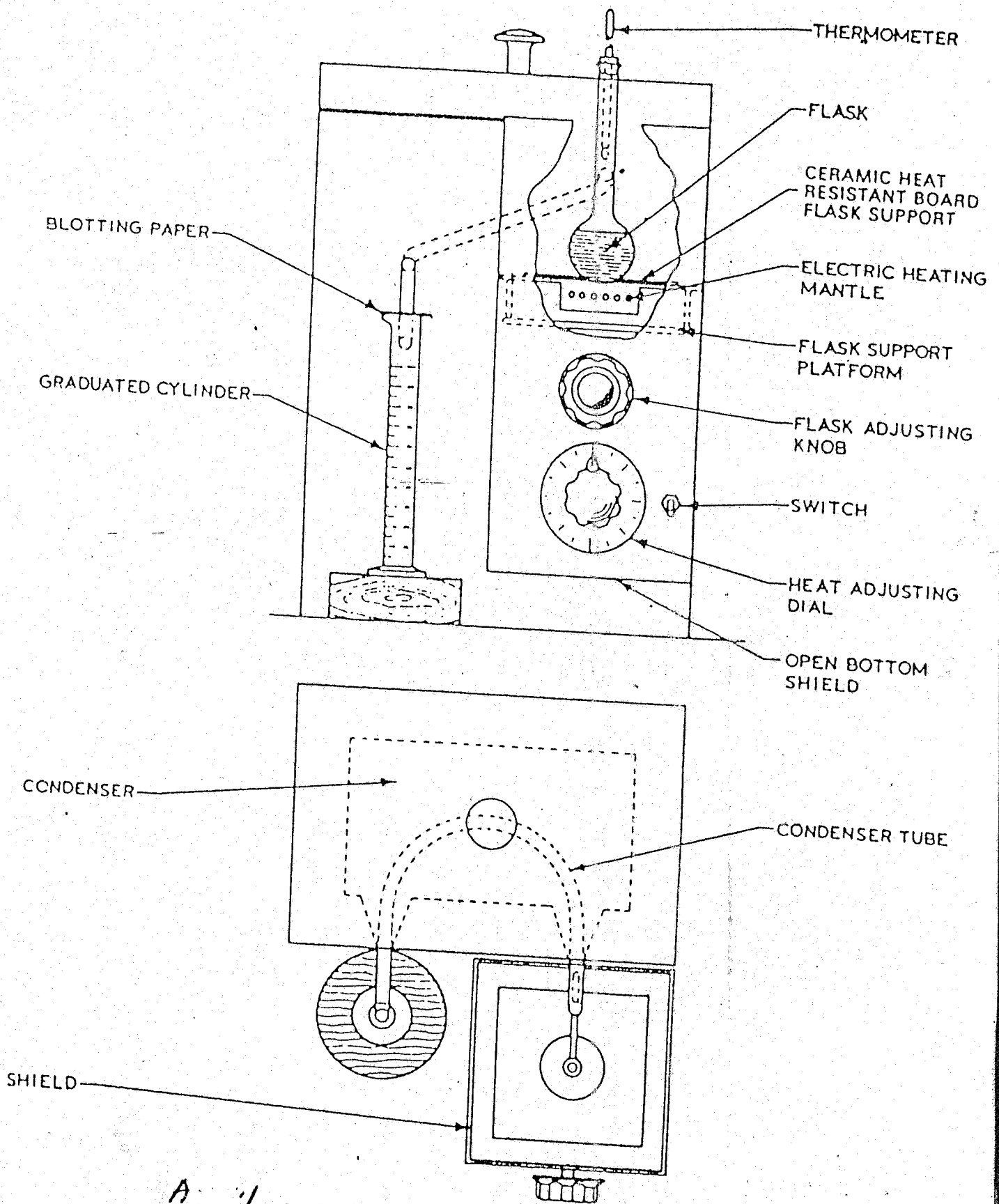
Apparatus

Test tubes, water bath, thermometer, test bomb, polishing vice, ropper strips.

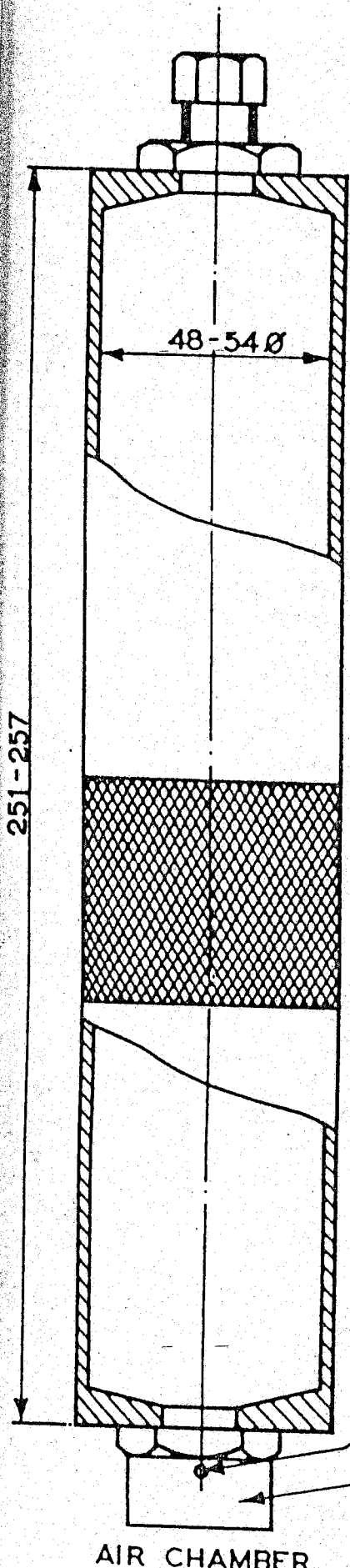
Procedure

30ml of the sample completely clear of and free of a suspended or entrained waste placed into chemically clear test tubes. The copper strip which polished for one minute will be inserted with a test tube containing the sample. The test tube was carefully slide into the test bomb and the slid was screwed tight. The bomb was then completely immersed in a boiling water bath at 100°C (212°F) the bomb was withdrawn from the bath, after 2 hour 15 minutes and thereafter it was immersed in a tap water. The bomb was opened and strip was withdrawn from the test tubes and it was examined in comparison with the corrosion standards.

DISTILLATION OF PETROLEUM PRODUCTS, IP 123



A. 1
Fig. 1. Apparatus assembly using electric heater.

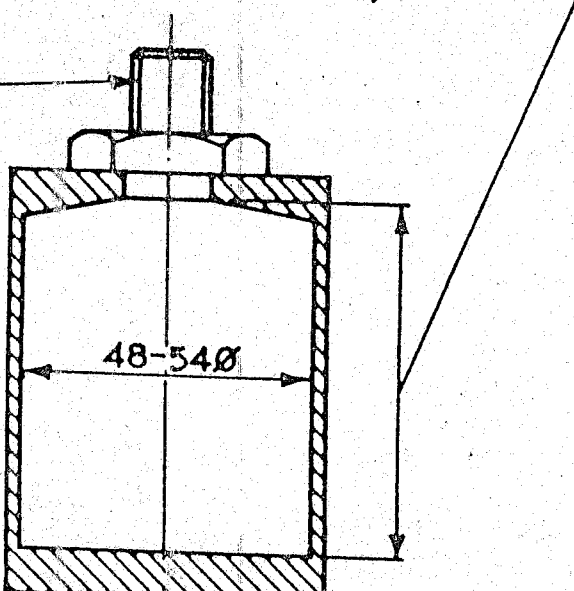


INTERNAL HEIGHT TO BE SUCH AS TO YIELD A VOLUME RATIO BETWEEN CHAMBERS OF NOT LESS THAN 3.95 NOR MORE THAN 4.05 (SEE ANNEX A1)

COUPLING
13 \varnothing MIN

VENT HOLE
COUPLING
13 \varnothing MIN

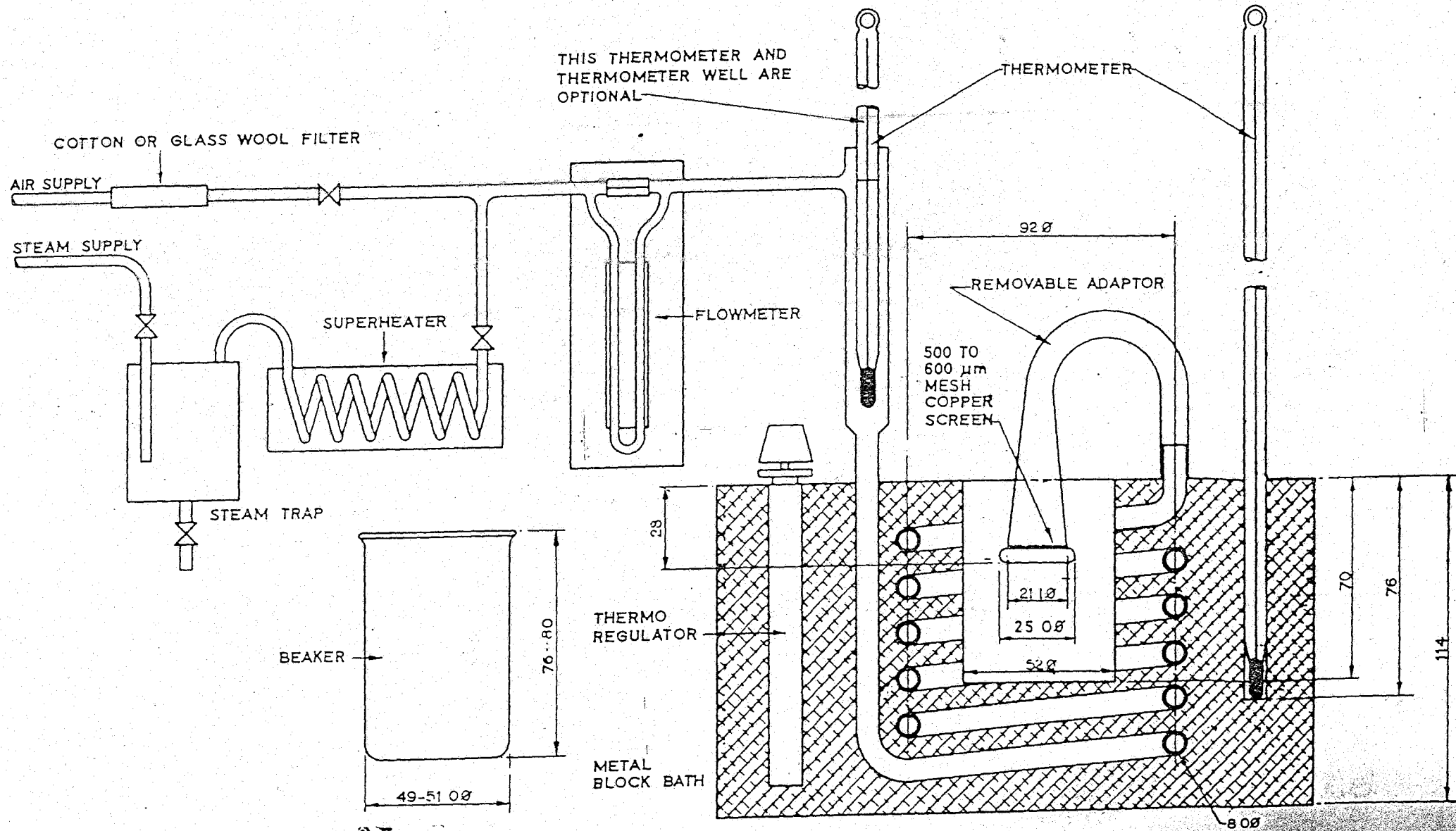
AIR CHAMBER



LIQUID CHAMBER
(ONE OPENING)

DIMENSIONS IN MILLIMETRES

Fig. A1. Vapour pressure apparatus.



93
 Fig. 4. Apparatus for determining existent gum by jet evaporation.

28

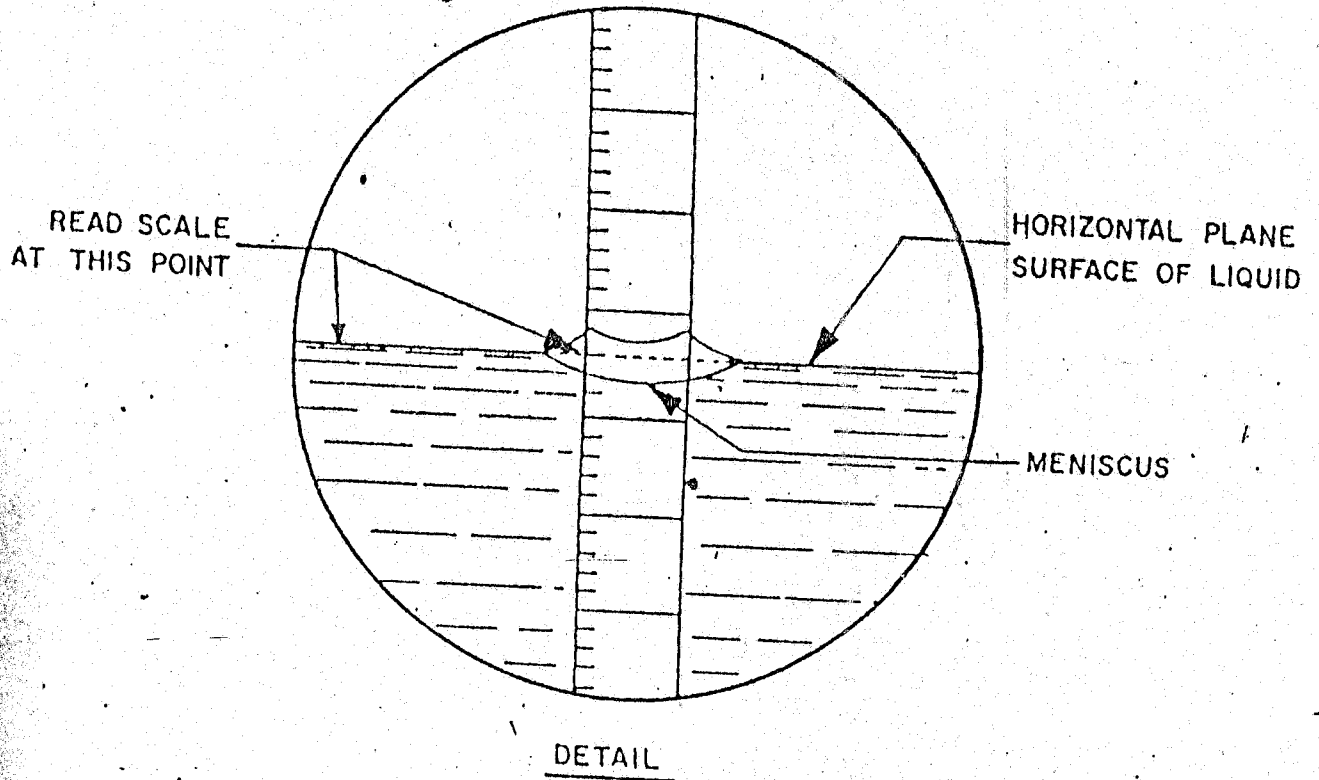
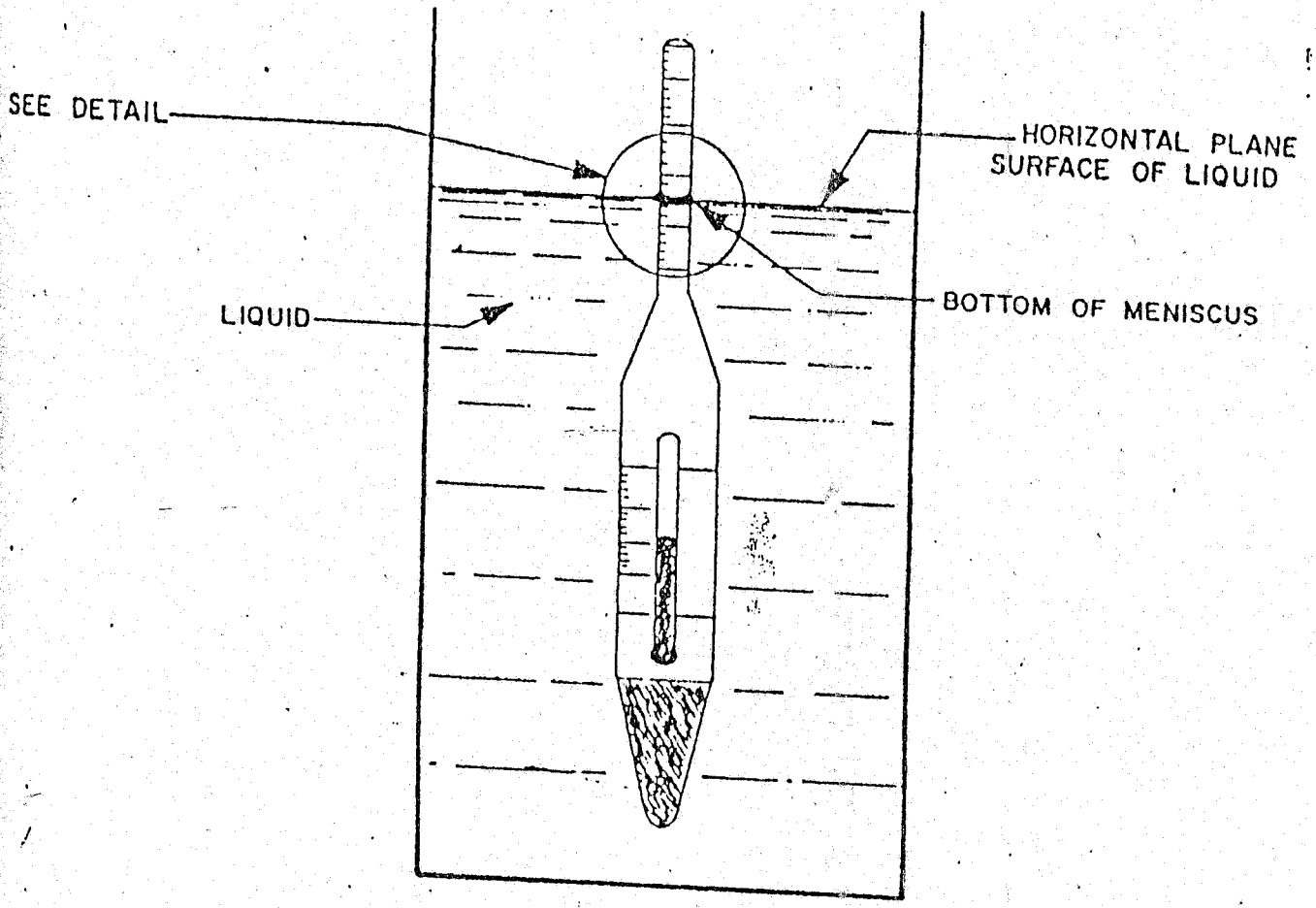
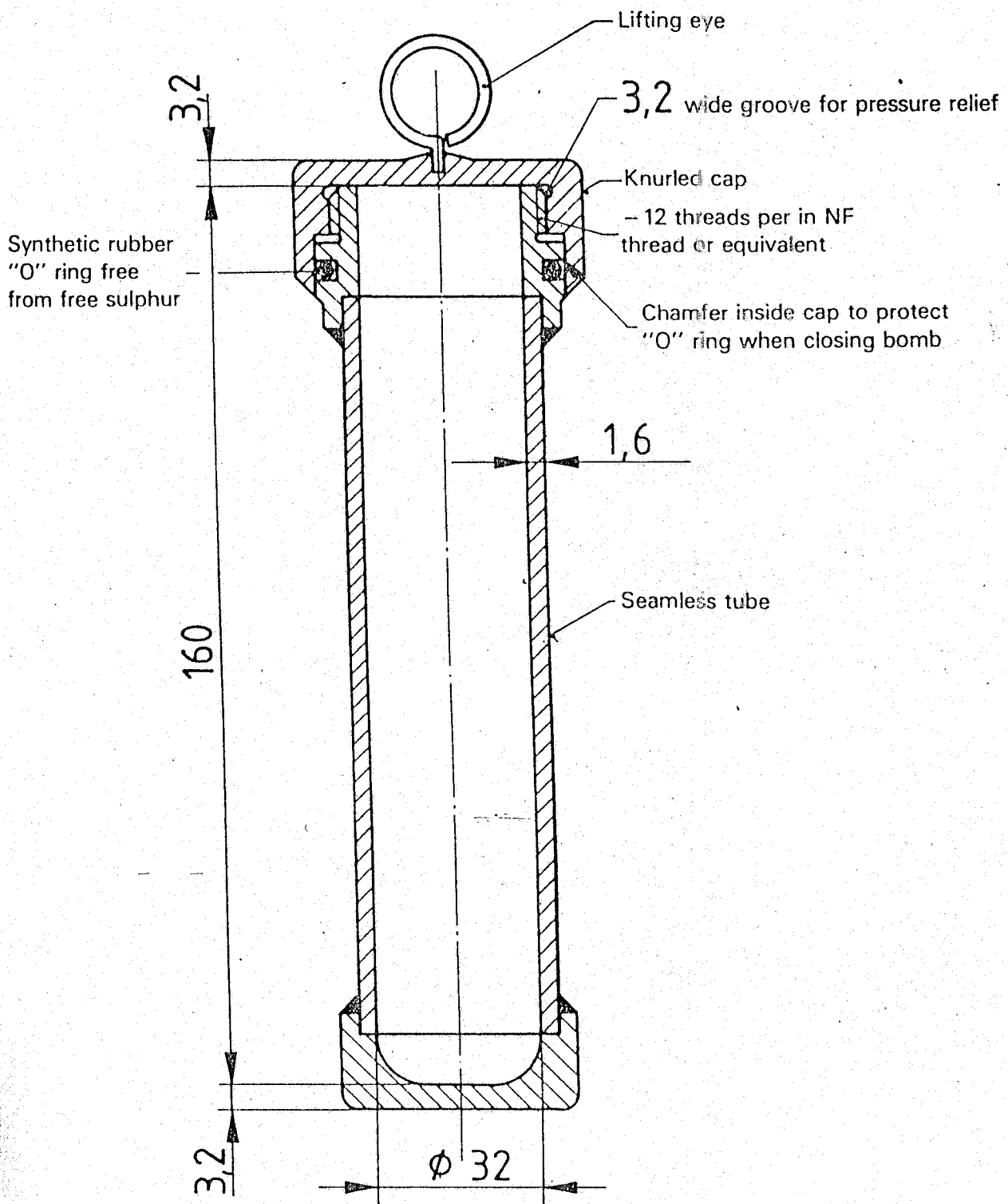


FIG. A Hydrometer Scale Reading for Transparent Liquids⁴

Dimensions in millimetres



Material: stainless steel
Welded construction
Maximum test pressure, gauge 700 kPa (7 bar)

Figure A: 5 Test bomb for the copper strip corrosion test

CHAPTER FOUR

4.0 RESULTS OF THE EXPERIMENTS

Average results for the experiments carried out were collected and presented in tabular form below.

4.1 Results obtained for premium motor spirit

Table 4.1 Results for Pms tests:

Tests	NNPC Ilorin	TOTAL	MOBIL	TEXACO	CONOIL
	AVG	AVG	AVG	AVG	AVG
SP.gr	726.1	732.3	731.4	741.5	746.9
Astm distill					
IBP °C	34	35	36	34	37
10% Recovery	52	54	54	52	56
20% “	63	64	65	63	68
30% “	73	78	79	73	78
40% “	86	87	88	86	92
50% “	104	108	108	105	110
60% “	118	120	122	118	122
70% “	131	136	138	132	135
80% “	146	151	152	146	152
90% “	165	169	169	165	174
95% “	184	188	188	184	188
FBP	193	197	198	194	202
%TR	99	98	97.5	98	97
Residue	0.5	1.5	2.0	1.5	2.5
Loss	0.5	0.5	0.5	0.5	0.5
R.V.P (Psi)	7.20	6.40	5.80	5.70	5.50
R.O.N	89.5	88.2	88.5	89.5	88.7
A.S.S.	+ve	+ve	+ve	+ve	+ve
Copper corrosion	1A	1A	1A	1A	1A
Existent gum content	2.01	3.10	2.20	1.60	2.5

Table 4.2 NNPC product specification for Pms

S/N	Test	MIN	MAX	Unit
1.	Specification 60/60 ⁰ f	0.74	0.76	
2.	Distillation			
	10%		70	⁰ C
	50%		125	⁰ C
	90%		180	⁰ C
	FBP		210	⁰ C
	% recovery	95	99	% volume
	% residue		5	% volume
3.	Research octane number	88	91	-
4.	Copper corrosion	-	Strip 101	-
5.	Reid vapour pressure	-	9.0	Psi
6.	Existent gum	-	4.0	Mg/100ml

4.3 Discussion of results

The performance evaluation of refinery product using premium motor spirit as case study was carried out by performing experiment on sample got from the selected filling stations and NNPC depot Ilorin. The product performance was done by comparing their results with NNPC standard specifications.

From table 4.1, the specific gravity (density) for product from NNPC Ilorin, Total, Mobil, Texaco and Conoil are 726.1, 732.3, 731.4, 741.5 and 746.9 respectively. The NNPC standard specification range is 710 – 760. Though value for specific gravity of the products varies with one another but they are all within the range of NNPC specifications.

For ASTM fractional distillation, the final boiling point of the product is the most importance. From the table 4.1, the final boiling point for product from NNPC, Total, Mobile, Texaco and conoil are 193, 197, 198, 194, and 202. The NNPC standard specification maximum value is 210, therefore all the products final boiling point value fall within the range.

The NNPC specification for research octane number (RON) is (88 – 91) from table4 4.1, the research octane number for the product are 89.5, 88.2, 88.5, 89.5 and 88.7. Though their values vary from one another, they all fall within the specification.

Also from the table 4.1, the RVP values for the product are 7.20, 6.40, 5.80, 5.70 and 5.50. They all less than maximum allowed RVP of

9.0psi in NNPC standard specification. Copper corrosion and existence gum content results also conform to NNPC specification.

After comparing all the results of the experiment with the NNPC standard specification, it was discovered that none of the products could yield

maximum performance but they are all fall within the NNPC specifications.

This was caused by the blending of good product with the contaminated product at NNPC depot to reduce the waste product at their locations. In doing this, it is always ensured that, the product properties still fall within the specification but this will surely reduce the performance of the products.

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATION

5.1 Conclusion

From the analysis of results, it could be concluded that the properties of the products were within the range of specification. This shows that the products from Total, Mobil, Texaco and Conoil in Ilorin are not adulterated. This could be due to the fact that D.P.K which is used for adulteration is more expensive than the Pms now.

5.2 Recommendation

The following recommendations should be employed:

1. This type of work should be carried out from time to time to help check adulteration.
2. Government should try to ensure that any company caught of adulteration is well punished to serve as a lesson to other companies.
3. The destructive methods of petroleum processing like the thermal and catalytic cracking, pyrolysis, reforming and conversion processes that give better and quality yield of gasoline. And refining products should be given more emphasis than the fractional distillation process.

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