



in association with



NIGERIA EXTRACTIVE INDUSTRIES TRANSPARENCY INITIATIVE

REPORT ON THE PROCESS AUDIT 1999-2004 REFINERIES AND PRODUCT IMPORTATION

APPENDIX H: METERING

Presented to
The National Stakeholder Working Group

by

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Final Submission

November 2006

Information as at 11th April 2006

The report and all appendices relating to the report are intended for the use of the National Stakeholder Working Group of the NEITI for the purpose of that initiative and are not to be relied upon by other parties.

APPENDIX H.1

TECHNICAL ASSESSMENT AND MEASUREMENT

DPR is responsible for the quantity measurement of crude oil & petroleum products.

Measurements are carried out by the DPR Terminal or Depot operators or their representatives and representatives of the operating companies. The DPR Terminal or Depot representatives report to their various supervisors and Heads of Departments who in turn report to the Director of Petroleum Resources through the operations controller.

This fiscalisation exercise is carried out to ascertain the accurate volume of crude oil and petroleum products both at the production units and custody transfer points.

The basic activities carried out during quantity determination using the dynamic method are flow metering and temperature measurement.

Flow Metering

This is the process of using a flow meter to measure the volume of liquid (i.e. crude oil or petroleum product) as it passes through the pipelines.

A flow meter of the positive displacement type is essentially a piece of equipment designed to measure volume of liquid by separating it into measured quantities (i.e. displaced volume) and counting these quantities. Flow meters of this type can only measure liquid in one direction, hence it is impossible to reverse the flow through such meters. Also these meters fitted to test separators and flow stations have never been calibrated since they were installed where they do not have a prover loop to calibrate the meter in situ.

Temperature Measurement

The temperature effect can account for the largest part of total error in quantity determination of petroleum product and crude oil. It is always necessary to compensate for the effect of temperature of the product.

The purpose of temperature measurement is to determine the temperature of the bulk liquid hydrocarbon (crude oil) in the storage tank.

The temperature so determined is used to calculate the standard volume of the crude oil at 60°F and its weight in tonnes. The operator who measured the level of the crude oil also measures the temperature. The temperature measurement method approved by DPR is the average temperature of the crude oil. The average temperature is obtained from the average of three (3) level measurements ($\frac{1}{6}$ of the crude level below the surface, middle of the crude oil, and $\frac{5}{6}$ th of the crude level below the surface).

Samples of the crude taken from the stated levels are measured for temperature using mercury in glass thermometer.

Necessary Checks

The temperature of the sample being measured must be at equilibrium with the temperature of the entire crude within that level. This is ensured by moving the sample can up and down in the crude column for about two minutes to allow for the can and its content to reach a temperature equilibrium within the crude in storage.

The reading of the temperature is taken when the thermometer reading is constant.

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The temperature Reading obtained from the level(s) temperature measurement is compared with the temperature back-up devices installed by the side of the tank (at various levels).

The temperature readings obtained together with the API (or S.G) is used to obtain the volume corrections factor (VCF), necessary for conversion of gross volume to standard volume at 60°F. The approved equipment for static measurement of temperature is mercury-in-glass thermometers.

Manual samples taken from the tank are decanted and shaken several times in the process of samples being taken and analysis rendering the sample not representative of the product being sold due to the loss of the light end component. The error is greater with lighter crude oils with a density > 35 deg API.

Upon completion of these activities, all the parties (i.e the DPR representative, operating companies representatives nominated representatives from buyers of cargo) usually compile the figures they had already collected independently and thereafter come together to cross check each other figures in order's to eliminate errors where necessary.

The process of producing the bills of lading is very laborious as numbers have to be typed into pre-printed forms which can lead to additional error. Wherever possible, the process should be computerised or otherwise automated.

After crosschecking each other's figures, all the parties would agree on a common/accurate figure and the DPR would issue certificate of quantity accordingly.

The certificate of quantity would then be circulated among the operating companies representatives, and the buyers of crude oil / product, as the case may be.

The frequency of this transaction, apart from the routine monthly fiscalisation is dependent upon the demand for the product.

The DPR arranges for replacement of their personnel when the incumbent is sick or on vacation.

List of sample as per attached / includes

- A copy of certificate of quantity
- Field data collection form for quantity determination

List of machines or equipment used for the exercise include

- Flow meters
- Thermometers

DOWNSTREAM – IMPORT

From Vessel to Depot Tanks

There are no metering activities from the Import Tankers to the depot Tanks. Hence quantity determination by metering cannot be carried out.

From Depot Tanks to Road Trucks

Meters are installed at the NNPC and Marketers Loading gantries for discharge of petroleum products from the depot tanks to the road trucks. The transaction is between the buyer and the operators. The DPR representatives always monitor the activities at the oil depots.

The operating company Personnel, and the buyer's representatives witness the discharge of product by the operator through the meter. After settling of product in the road truck the quantity of product is jointly ullaged using ullage bar to reconfirm the metered quantity. If there are no discrepancies between the quantity, a Certificate of Quantity shall be issued by operators management and circulate accordingly.

Export

Export activities at the downstream sector is mainly carried out by NNPC and few other marketers. This is done by transferring product from depot tank through the pipeline to the export vessel.

Quantity determination by metering is not possible since there are no metering facilities installed both at the depot tank and tankers for such activities.

STATIC MEASUREMENT

Tank Gauging (Fiscalisation)

Tank gauging or fiscalisation is the measurement of the level of a liquid hydrocarbon in storage tank with approved steel tape in order to ascertain the level of the liquid hydrocarbon contained in the storage tank. (shore or offshore). The liquid hydrocarbon can be crude oil or petroleum product(s).

The measured level of the crude oil or products (as the case may be) is converted into volume from certified tank calibration charts. Tanks are certified every 5 years after they have been cleaned and re-furbished.

The tank to be fiscalised must meet the required conditions as approved by the Government regulatory agent (DPR).

Measurement of liquid hydrocarbon level (Fiscalisation) can be either by dipping (innage) or ullage method. The approved method by DPR is dipping in innage.

The person that carries out the gauging exercise for custody transfer purposes can be either DPR representative or representative of the operating terminal while other (DPR or Terminal operator's representative) witnesses. Before the quantity could be accepted, the measured value (level) should repeat itself for at least 2 consecutive readings

Necessary Checks Include:

The tank content (crude oil / products) must be stabilised by allowing the content to settle for the minimum period specified for that grade of crude oil or products. For crude oil, minimum settling time is 6 hours after filling the tank.

The segregated free water in the tank is removed through draining of the tank.

- The storage tank should have been calibrated by a DPR accredited company.
- All equipment for gauging must meet the stipulated specifications.

- The crude oil surface in the tank should be free of foam or waves due to agitation.
- The gauge hatch should be free of debris from the roof to the datum plate.

The steel tape is rubbed with a paste (chemical) to give a good contrast between the portions wetted by crude (cut) from the remaining dry portion of the tape upon withdrawal from the crude oil surface. This is the wording of the DPR guideline but it was not observed during the fiscalisation process at two terminals even though DPR Inspector was witnessing this operation.

Frequency of Measurement (Fiscalisation):

The frequency of crude oil tank fiscalisation can be classified into 5 frequencies:

- i. Fiscalisation after tank filling (production)
- ii. Daily fiscalisation
- iii. Biweekly fiscalisation
- iv. Monthly fiscalisation
- v. Fiscalisation for Export.

The procedure for all fiscalisation exercise is identical

Daily Fiscalisation

This is a fiscalisation carried out every morning to check the volume of crude oil in each tank and when combined becomes the crude oil stock in the terminal. During the daily fiscalisation, the free water level of each tank as well as the water content of crude from laboratory analysis, are noted for appropriate action.

BI-Weekly Fiscalisation

This is similar to the daily fiscalisation except that it is carried out in preparation for the end of the month material balance.

Monthly Fiscalisation

This is the fiscalisation carried out at the end of each month to facilitate the monthly material balance. During the monthly stock balancing, both

DPR and terminal operators reconcile the quantity of crude oil (volume, and weight) produced during the month quantity exported, and balance stock figures are reconciled and documented.

QUALITY DETERMINATION

Quality determination refers to the processes involved in ascertaining the quality of the crude oil in terms of API / S.G at 60/60, base sediment and water (suspended).

The first stage of quality determination is sampling, followed by laboratory analysis.

Sampling:

The purpose of sampling is to obtain a truly representative composite sample of the contents of a tank to be used in determining the quality of the crude in the storage tank.

The sample collecting device is called THIEF CAN. The sample thief can should be a corrosion – resistant metal.

The number of samples to be taken from crude in tank storage is dependent on the depth of the crude oil as follows:

LEVEL	NO OF SAMPLES	SAMPLING POSITION
3M and below	1	Middle
3M to 4.6M	2	Upper and lower
Above 4.6M	3	Upper, middle, and Lower

A wrong sampling gives a wrong analytical results(s), therefore good sampling is important for accurate quality results.

Necessary Precautions

- Sampling takes place immediately after gauging.
- The sampling apparatus including the holding cord should be clean and free of any contaminants.
- The Cord should be made of material that does not accumulate static electricity.
- The sample container should be closed immediately it has been withdrawn from the tank to prevent the entry of water from external sources
- The thief can should be filled at the desire depth before withdrawing it to the surface.
- When samples are required from more than one level in a tank the order of sampling should be from the top downwards so that each sample will be obtained before the liquid at that level is agitated.

For samples arising from export operation, the level samples are pooled into one big sample and divided into four (4) of two litres each and distributed as follows.

- a. One (Two – Litre) sample to the terminal laboratory for quality analysis.
- b. One (two-litre) sample to the laboratory for retention for a period of 90 days.
- c. Two (Two – Litre) samples handed over to the export vessel for the consignees quality analysis.

Every sampling is accompanied by temperature measurement as described.

API Determination

API refers to the density of the crude. The higher the API, the lighter the density and hence the higher the price of the crude oil.

Apart from price index determination, API (or specific gravity, S.G) is used with the crude tank temperature to calculate the standard volume, and weight (Long ton) of the crude oil. The API gravity is determined, using approved hydrometer and hence requires the sample to be representative.

Quality Analysis

The terminal laboratory chemist carries out quality analysis in the laboratory. A typical quantity certificate is produced in a copies. The original copy goes to NNPC Crude Oil Marketing, if the crude oil being Exported is NNPC equity. DPR, the consignor and consignee receive a copy each.

PARAMETERS USED IN COMPUTATION OF CRUDE QUANTITIES

Tank Dip

This is the height of the column of oil in the tank as obtained from the gauging exercise.

Volume Reduction factor

This is obtained by first establishing the specific gravity of the sample at 60F from table 23A of the revised ASTM4P measurement table volume IV or the API gravity at 60^o F from Vol. 1 table 5A of the measurement table. The corresponding volume reduction factor is then obtained by referring the API gravity at 60/60 F to table 24A or 6A of the measurement table respectively.

Long Tons Per Barrel Factor

This is obtained by referring the API gravity or S.G at 60/60F to ASTM-IP Volume XI/XII table ii and 29 respectively.

Calculation For Fixed Roof Tanks

The tank dip is referred to the appropriate tank calibration table to obtain the gross quantity of oil in barrels at tank temperature, thereafter the quantities are calculated as follows:

Gross Standard Volume At 60/60 F

This is obtained by multiplying the gross volume at tank temperature by the volume reduction factor.

Gross Weight

The gross volume in barrels at 60/60 F is than multiplied by the long ton per barrel factor to give the equivalent weight in long tone at 60/60 F.

Net Volume And Weight Of Oil In Tanks

The net volume of oil in the tank is obtained from the subtraction of the volume of water from the gross volume of oil while the weight of water is subtracted from the gross weight of oil in the tank at 60/60 F to obtain the net weight of oil in the tank.

Calculation For Floating Roof Tanks

The only difference to note when calculating the crude oil quantity in a floating roof tank is that, correction has to be made for the roof displacement which in turn depends on the weight of the roof and specific gravity at tank temperature of the crude in storage.

For the correction to be valid, however, the roof should be fully floating. In most cases, floating roof displacement charts are either provided along with the calibration table of the tank or in the alternative is supplied.

Convert the SG of crude at laboratory temperature to that at 60/60F by using the revised ASTM table 23A. Then obtain the SG of crude oil at tank temperature by converting that at 60/60 F using the same ASTM table 23A.

Calculating the roof displacement by using the relationship $W/T = \text{Displacement}$, where W = Weight of the roof in long tone as given in the relevant tank table, and T = density at tank temperature.

Subtract the roof displacement to obtain the gross volume of tank content at tank temperature to obtain the gross volume of crude oil in stage in barrels. (Tank content at tank temperature is obtained by referring the tank dip to appropriate tank calibration table).

Thereafter, proceed with other calculations to obtain the net volume and weight of crude oil in the tank.