# Effect of Variable Conversion Factor on Data Reliability

**Grace C. Akujobi-Emetuche, Ogbonna F. Joel, Franklin O. Chukwuma, Emenike N. Wami**

*Abstract*— **Field operations figures collected from three pipeline segments showed that most of the data generated in different measurement units are inconsistent. Therefore, these raw figures lead to complexity in stock accounting, reconciliation and inconsistency in pipeline delivery figures. The objective of this work is to establish a simplified procedure that will proffer solution to the discrepancies and aid in quick resolution of the inconsistencies in petroleum and petroleum products delivered through the pipeline. Figure 1 has the percentage difference in volume and weight as 0.16% and 0.37% respectively, Figure 2, has the percentage difference in volume and weight as 9.5% and 9.46. Figure 3 has the percentage difference in volume and weight as 0.62% and 0.58%. The rule of thumb to check the conversion was established as 7.31. This procedure can be applied to other petroleum products delivered through the pipeline. This procedure no doubt would help to minimize overblown losses, instill professional checks, and present reliable figures to end users.**

*Index Terms*— **Data, measurement units, petroleum, petroleum products, pipeline, conversion factor**

## I. INTRODUCTION

Emerging oil and gas industries with entrepreneurial mindset need varied measurement units to ensure reliable petroleum and petroleum products accounting. The ability to navigate from one basic engineering measurement to another is an advantage to producers and users who evaluate their transactional performance in line with prevailing industry standards. Most specialized calculations in oil and gas industries are done through established processes and procedures. Comprehensive review of field records revealed that the stock figures presented in volume and its equivalent weight are not consistent. It was also observed that in some reports, differences were declared as negative in weight and positive in the volume equivalent. The inconsistency leads to poor stock accounting and complexity in reconciliation. For the calculated figures to be reliable and useful for decision making, the data has to be consistent in all industry units.

This study therefore examined the inconsistency in the figures presented in weight and the equivalent in volume. It also established the effect of the inaccurate figures on pipeline delivery, hence the need for simple model as rule of thumb to confirm pipeline generated data.

### 1.1 DATA

Data is defined as a stream of raw facts representing events occurring in organizations or physical environment before they have been organized and arranged into form that people can understand (Geisler, 2007). Businesses are rapidly changing, coupled with the pressure to reduce cost and develop new opportunities. Therefore decision should no longer be based on judgement or gut feeling. For the data to be reliable for sound decision making, it has to be collected, compiled, verified, validated and organized (Anderson, 2000).

### 1.2 PETROLEUM AND PETROLEUM PRODUCTS

The term petroleum may refer to hydrocarbon in both gaseous and liquid states which are found in nature in raw or unrefined (hence the word Crude oil) forms and are separated into different fractions to produce a variety of products. These products are transportation fuels like natural gas, gasoline, house hold kerosene, aviation fuel, lube oil, and petrochemical products (Dandekar, 2010). Petroleum (conventional crude oil ranges from a brownish to black liquid having specific gravity that varies from 0.75 to 1.0 (Speight, 2014). The derivatives from petroleum contribute from one-third to one-half of the total world energy supply and are used for transportation fuels (Speight, 2009) in line with Dandekar (2010) presentation.

Wiehe applied chemical engineering approach in his research. He used hydrogen content and hydrogen balance to evaluate constants in chemical kinetics, measured the attraction energy among petroleum macromolecules, characterized the building blocks and determined the maximum yield from a coking process. The outcome is that petroleum is actually not so complex because it is composed of mostly carbon, hydrogen and sulfur atoms (Wiehe, 2008).

The American Society for Testing Materials (ASTM D4175) describes petroleum as a naturally occurring mixture of hydrocarbons, generally in a liquid state which may also include compounds of Sulphur, nitrogen, oxygen, metals and other elements (Speight, 2015). In another presentation, Speight and Ozum (2009) described petroleum as a mixture of gaseous, liquid, and solid hydrocarbon compounds that occur in sedimentary rocks deposits throughout the world. From Dandekar (2010), work, this study will prefer to use the terminology crude oil instead of petroleum in the rest of the work. Crude oil is mixtures of pure components. It has physical and chemical characteristics that vary widely from one field to another and even within the same field. Crude oil can be classified as light and heavy. Since crude oil is composed of hydrocarbons molecules, its specific gravity varies inversely with the hydrocarbon atomic ratio. The specific gravity of various crude oil ranges from 0.7 to 1.0 and is often expressed as degree API (American Institute of

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America) which may vary between 70 and 5. The variable gravity reflects compositions of chemical families that are very different from each other. The most economic attraction in any crude oil is the gasoline fraction. Some can yield up to 37% by volume while others can yield as low as 4.5%. He also stated that these differences influence the conditions of production, transport, storage and refining adopted. The difficulty to describe the different fractions increases with the number of carbon atoms. Some of the parameters used in classifying the crude oil include their specific gravity, API gravity, characterization factor or Watson factor, boiling point, (Wauquier, 1995). Specific Gravity (S) is linked to American Petroleum Institute (API) degree and is expressed as

$$API = \frac{141.5}{S} - 131.5 \qquad (1)$$

### 1.3 PIPELINE DELIVERY CHALLENGES

The desires of the oil and gas industries are to ensure safety and security of lives and properties. To guard against sabotage, vandalism, terrorist action and ensure timely reporting of probable in-line equipment failures, the companies have adopted strategies for peaceful collaborating with host communities and other relevant stakeholders.

According to Joel and Udofia, (2012), Pipelines and Products Marketing Company (PPMC) Limited, is charged with the responsibility of transporting crude oil to the nation's refineries and evacuating the refined petroleum products for supply and distribution throughout the country. Their research stated that PPMC achieves this through its operations and maintenance of an extensive network of pipelines covering about 5200 kilometers linking the nation's four (4) refineries. Malicious destruction of pipelines and repairs has equally affected delivery calculations and performance.

### 1.4 OIL AND GAS INDUSTRY MEASUREMENT UNITS

For completeness, transparency and ease in interpretation by the end users, data generated from pipeline pumping operations, should be presented in two or three equivalent oil and gas industry measurement units. Understanding of the principles of basic measurement units will help the industries to properly evaluate their performance in line with their relevant operations. The use of measurement units helps in the development of systematic problem solving skills; understand the need for material balance, its formulation, application and solution. It should be noted that knowledge of units and measurements of physical properties, basic laws about the behavior of liquids and basic conversion tools are paramount in petroleum and petroleum products accounting (Himmelblau, 2012). According to Himmelblau (2012), the measurements or units employed by any organization depend most times on the regional or national preference. Petroleum and petroleum products can be measured in weight, volume and thermal energy. To confirm reservoir or storage tank content and available space, most engineers measure in volumes. Marine operators will prefer to measure in weight to avoid overloading their vessels while thermal energy is preferred by marketers when the products sold are for fuel purposes.

### 1.5 CONVERSION FACTORS

Conversion factors are statements of equivalent values of different units in the same system or between systems of units. It is done by multiplying any number and its associated units with dimensionless ratios in order to arrive at the desired value and the associated units. The tools for the measurement are principles of dimensions and units.

Dimension and units are physical quantities used to describe the natural laws. These physical quantities are defined by the measurement instructions and are determined by basic or primary measuring units such as meters for length, kilograms for weight and Celsius of Fahrenheit for temperature and time for duration (Ghosal, 2011).

The use of conversion factors will prevent inadvertent inversion of any part of the figure. Sound understanding the conversion process will aid in reducing figure reconciliation time, and interpretation of physical meaning of the numbers presented in any unit.

### 1.6 DIMENSIONAL CONSISTENT

The basic rule is that each term in an equation must have the same net dimensions and units as every other term to which it is added or subtracted from. Other ways of confirming the consistency of presented numbers are through some decision criteria named as absolute error, relative error and statistical analysis (Himmelblau, 2012).

## II. METHODOLOGY

### 2.1 Presumed inconsistencies in some field data

The steps taken in the analysis are:

- Collated pumped and received raw data from Chevron-Escravos, Escravos-Warri, and Warri-Kaduna pipeline segments are presented in Appendices A-1 to A-3
- The set of data from each pipeline segment was presented in metric tons (weight) with its equivalent in barrels (volume).
- The difference and the percent difference between the pumped and the received figures in both units were calculated.
- Scrutinized the difference carefully and observed that some values appeared as positive while others are negative. Check for uniformity in the figures.
- Graphical presentations of the percent differences were made to enable better visual guide and interpretation of physical meaning of the numbers used.
- Determined how close the figures are acceptable industry standard.
- The information obtained at this juncture led to further calculation that would correct non-uniformity in pipeline delivery figures.

### 2.2 Procedure for correcting observed non-uniformity in pipeline figures.

This sector uses input from section (3.72) to start the process the steps are as follows:

- Extracted the differences from the main table.
- Tested for consistency factor of the barrel and metric tons figures by dividing the numbers in barrels by the numbers in metric tons.
- Divergent results were observed.
- Rearrange the results in ordered form (ascending or descending)

- Used statistical trimmed mean to trim both extremes of the ordered data by 22%.
- Summed the remaining figures, and then calculated the arithmetic mean Compared the mean calculated with theoretical conversion factor.
- Validated Conversion factor must be within internationally acceptable range.
- The calculated factor is also called simple rule of thumb for consistency checks.
- For light Petroleum oil, the oil conversion factor from weight to volume is in the range of 7.3 to 7.35 (Donohue, 2014). Converting from barrels to metric tons requires that the figure in barrel be divided by the chosen factor. Alternatively, figure in barrel can be multiplied by the inverse of the same factor.

## III. RESULTS AND DISCUSSION

### 3.1 RESULTS

#### 3.1.1 PUMPED AND RECEIVED FIGURES

The pumped and received figures from field records were tabulated. The difference and percentage difference were calculated to ascertain the consistency. Charts were also used to demonstrate the departure from the global acceptable factors.

**Table 1** Pumped and received figures including percent difference on Segment 1

| MONTH / YEAR | AS COLLATED FROM FIELD | | | | RESEARCH CALCULATIONS | | | |
|---|---|---|---|---|---|---|---|---|
| | PUMPED | | RECEIVED | | DIFFERENCE | | % DIFFERENCE | |
| | BBLS | MT | BBLS | MT | BBLS | MT | B | M |
| November, 2004 | 199,792 | 27,053 | 205,357 | 27,761 | 5,565 | 708 | 2.79 | 2.62 |
| February, 2005 | 1,380,385 | 187,446 | 1,373,007 | 186,100 | -7,378 | -1,346 | 0.53 | 0.72 |
| March, 2005 | 1,410,085 | 191,645 | 1,410,428 | 191,470 | 343 | -175 | 0.02 | 0.09 |
| April, 2005 | 1,426,544 | 193,774 | 1,426,763 | 193,755 | 219 | -19 | 0.02 | 0.01 |
| May, 2005 | 2,486,820 | 338,088 | 2,483,602 | 337,145 | -3,218 | -943 | 0.13 | 0.28 |
| June, 2005 | 2,665,159 | 362,721 | 2,610,846 | 354,591 | -54,313 | -8,130 | 2.04 | 2.24 |
| July, 2005 | 3,347,921 | 452,752 | 3,381,290 | 458,539 | 33,369 | 5,787 | 1 | 1.28 |
| August, 2005 | 2,108,852 | 287,043 | 2,109,448 | 286,321 | 596 | -722 | 0.03 | 0.25 |
| September, 2005 | 2,476,788 | 336,399 | 2,474,722 | 335,676 | -2,066 | -723 | 0.08 | 0.21 |
| October, 2005 | 3,453,215 | 469,375 | 3,440,380 | 467,195 | -12,835 | -2,180 | 0.37 | 0.46 |
| November, 2005 | 1,582,189 | 215,408 | 1,584,563 | 215,133 | 2,374 | -275 | 0.15 | 0.13 |
| January, 2008 | 535,012 | 78,056 | 469,388 | 63,813 | -65,624 | -14,243 | 12.27 | 18.25 |
| February, 2008 | 2,307,981 | 315,217 | 2,364,316 | 322,975 | 56,335 | 7,758 | 2.44 | 2.46 |
| March, 2008 | 3,106,690 | 424,436 | 3,099,886 | 422,705 | -6,804 | -1,731 | 0.22 | 0.41 |
| April, 2008 | 2,539,624 | 346,977 | 2,534,396 | 345,240 | -5,228 | -1,737 | 0.21 | 0.5 |
| May, 2008 | 2,009,329 | 274,729 | 2,008,485 | 275,482 | -844 | 753 | 0.04 | 0.27 |
| June, 2008 | 2,918,255 | 398,013 | 2,919,670 | 397,170 | 1,415 | -843 | 0.05 | 0.21 |
| **TOTAL** | **35,954,641** | **4,899,132** | **35,896,547** | **4,881,071** | **-58,094** | **-18,061** | **0.16** | **0.37** |

(Source: Excerpts from PPMC sampled field data, 2004 to 2008 Chevron-Escravos pipeline).

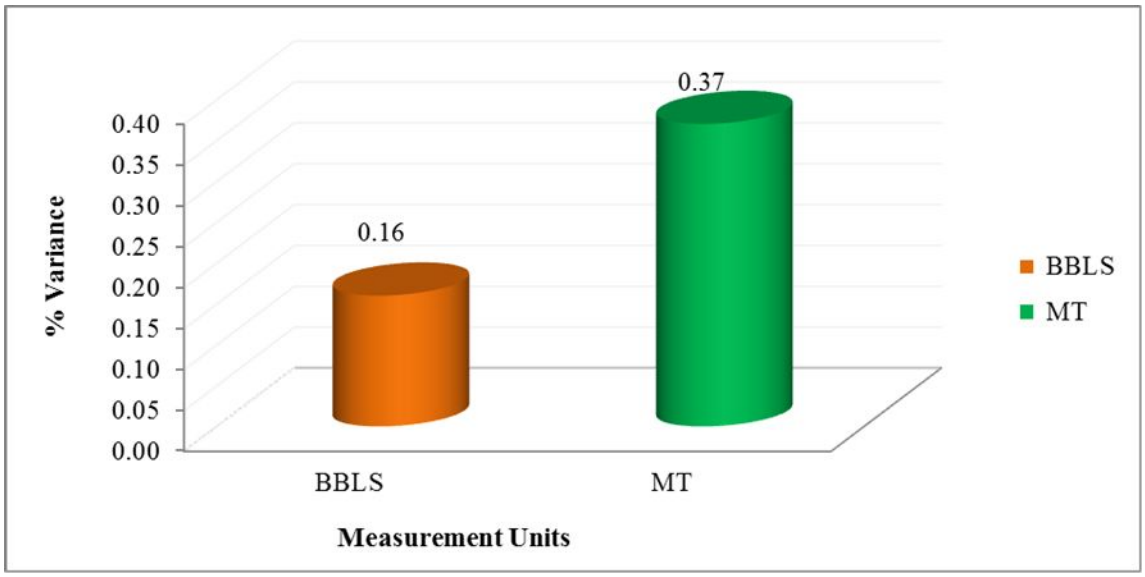


**Figure 1:** Inconsistency in C-E pipeline segment data presented in volume and the equivalent in weight.

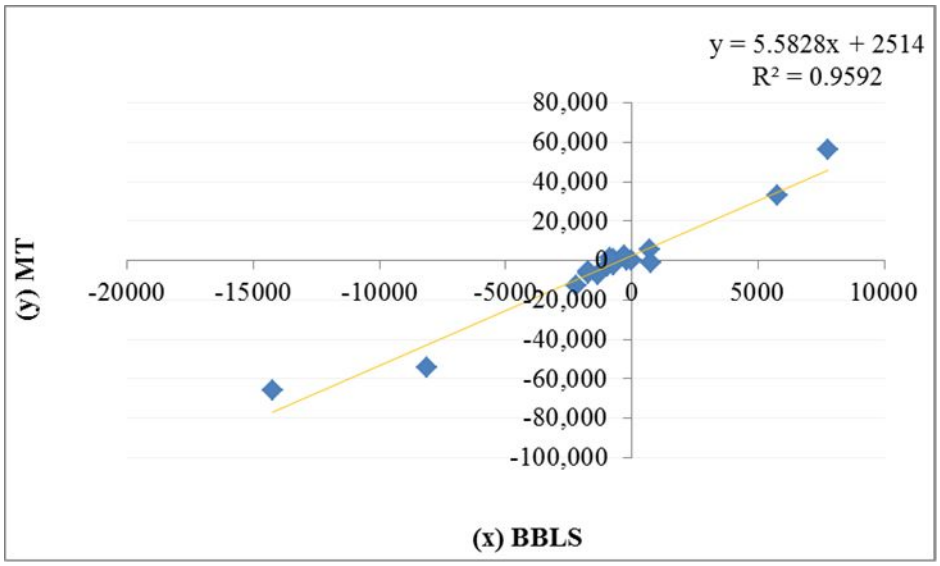


**Figure 2:** Plot of pumped and received difference in weight and volume (C-E segment)

**Table 2** Pumped and received figures including percent difference on Segment 2

| MONTH /YEAR | AS COLLATED FROM FIELD | | | | RESEARCH CALCULATIONS | | | |
|---|---|---|---|---|---|---|---|---|
| | PUMPED | | RECEIVED | | DIFFERENCE | | % DIFFERENCE | |
| | BBLS | MT | BBLS | MT | BBLS | MT | B | M |
| November, 2004 | 375,183 | 50,667 | 353,424 | 47,505 | -21,759 | -3,162 | 5.8 | 6.2 |
| February, 2005 | 1,572,490 | 213,032 | 1,449,246 | 196,183 | -123,244 | -16,849 | 7.8 | 7.9 |
| March, 2005 | 1,819,607 | 236,927 | 1,541,309 | 209,344 | -278,298 | -27,583 | 15.3 | 11.6 |
| April, 2005 | 1,824,868 | 248,601 | 1,572,772 | 213,897 | -252,096 | -34,704 | 13.8 | 14 |
| May, 2005 | 2,437,331 | 330,939 | 2,125,219 | 288,443 | -312,112 | -42,496 | 12.8 | 12.8 |
| June, 2005 | 2,848,878 | 384,954 | 2,603,867 | 353,746 | -245,011 | -31,208 | 8.6 | 8.1 |
| July, 2005 | 3,031,081 | 410,912 | 2,614,000 | 354,765 | -417,081 | -56,147 | 13.8 | 13.7 |
| August, 2005 | 2,741,364 | 372,931 | 2,380,728 | 323,208 | -360,636 | -49,723 | 13.2 | 13.3 |
| September, 2005 | 3,105,529 | 422,189 | 2,995,590 | 407,363 | -109,939 | -14,826 | 3.5 | 3.5 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| October, 2005 | 2,774,965 | 377,456 | 2,593,044 | 352,009 | -181,921 | -25,447 | 6.6 | 6.7 |
| November, 2005 | 3,049,100 | 415,493 | 2,687,991 | 365,761 | -361,109 | -49,732 | 11.8 | 12 |
| December, 2005 | 3,892,640 | 29,435 | 3,778,600 | 513,886 | -114,040 | -15,549 | 2.9 | 2.9 |
| January, 2008 | 707,570 | 96,220 | 783,952 | 106,030 | 76,382 | 9,810 | 10.8 | 10.2 |
| February, 2008 | 2,216,685 | 301,757 | 2,172,103 | 294,178 | -44,582 | -7,579 | 2 | 2.5 |
| March, 2008 | 3, 471,203 | 473,231 | 2 ,795,588 | 379,474 | -675,615 | -93,757 | 19.5 | 19.8 |
| April, 2008 | 2,242,581 | 305,677 | 1,953,659 | 265,581 | -288,922 | -40,096 | 12.9 | 13.1 |
| May, 2008 | 2,830,599 | 386,149 | 2,721,359 | 371,019 | -109,240 | -15,130 | 3.9 | 3.9 |
| June, 2008 | 3,100,599 | 422,235 | 2,733,607 | 370,993 | -366,992 | -51,242 | 11.8 | 12.1 |
| TOTAL | 44,042,273 | 5,978,805 | 39,856,058 | 5,413,385 | -4,186,215 | -565,420 | 9.5 | 9.46 |

(Source: Excerpts from PPMC field data, 2004 to 2008 Escravos-Warri pipeline segment).

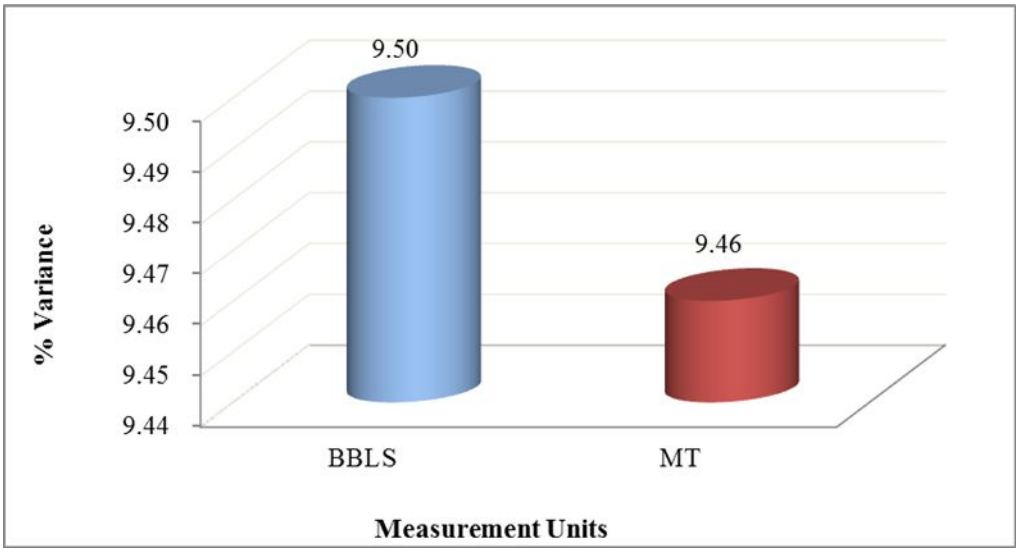


**Figure 3:** Inconsistency in E-W pipeline segment data presented in volume and the equivalent in weight.

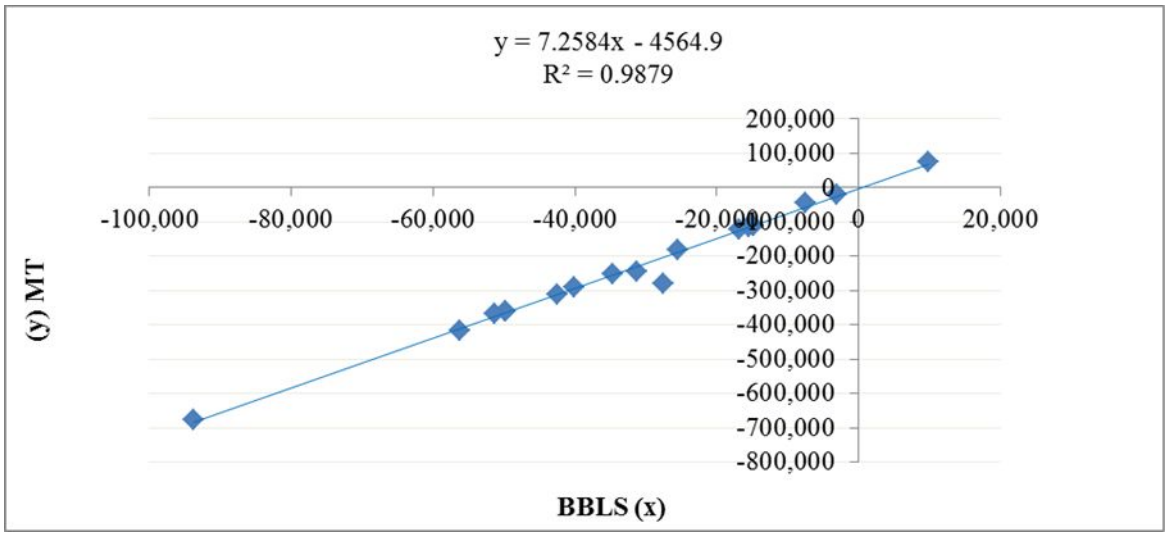


**Figure 4:** Plot of pumped and received difference in weight and volume (E-W segment)

**Table 3** Pumped and received figures including percent difference

| MONTH / YEAR | AS COLLATED FROM FIELD | | | | RESEARCH CALCULATIONS | | | |
|---|---|---|---|---|---|---|---|---|
| | PUMPED | | RECEIVED | | DIFFERENCE | | % DIFFERENCE | |
| | BBLS | MT | BBLS | MT | BBLS | MT | B | M |
| February, 2005 | 978,999 | 133,473 | 994,301 | 135,547 | 15,302 | 2,074 | 1.56 | 1.55 |
| March, 2005 | 1,638,362 | 224,449 | 1,616,824 | 221,578 | -21,538 | -2,871 | 1.31 | 1.28 |
| April, 2005 | 1,483,116 | 201,981 | 1,483,494 | 202,627 | 378 | 646 | 0.03 | 0.32 |
| May, 2005 | 1,203,146 | 163,252 | 1,199,361 | 162,783 | -3,785 | -469 | 0.31 | 0.29 |
| June, 2005 | 1,191,858 | 162,003 | 1,170,838 | 159,539 | -21,020 | -2,464 | 1.76 | 1.52 |
| July, 2005 | 1,573,820 | 213,839 | 1,583,587 | 214,554 | 9,767 | 715 | 0.62 | 0.33 |
| August, 2005 | 836,290 | 113,824 | 793,693 | 107,837 | -42,597 | -5,987 | 5.09 | 5.26 |
| September, 2005 | 1,329,121 | 180,070 | 1,314,185 | 178,298 | -14,936 | -1,772 | 1.12 | 0.98 |
| October, 2005 | 1,226,447 | 167,423 | 1,265,756 | 172,835 | 39,309 | 5,412 | 3.21 | 3.23 |
| November, 2005 | 958,025 | 130,325 | 955,175 | 130,068 | -2,850 | -257 | 0.3 | 0.2 |
| December, 2005 | 1,222,658 | 166,062 | 1,196,762 | 162,930 | -25,896 | -3,132 | 2.12 | 1.89 |
| March, 2008 | 1,059,336 | 143,967 | 1,037,460 | 138,989 | -21,876 | -4,978 | 2.07 | 3.46 |
| April, 2008 | 833,264 | 112,347 | 871,270 | 118,167 | 38,006 | 5,820 | 4.56 | 5.18 |
| May, 2008 | 432,618 | 57,742 | 387,129 | 51,614 | -45,489 | -6,128 | 10.51 | 10.61 |
| June, 2008 | 750,167 | 100,680 | 744,002 | 101,002 | -6,165 | 322 | 0.82 | 0.32 |
| **TOTAL** | **16,717,227** | **2,271,437** | **16,613,837** | **2,258,368** | **-103,390** | **-13,069** | **0.62** | **0.58** |

(Source: Excerpts from PPMC System 2C monthly report, 2004 to 2008 Warri - Kaduna pipeline segment).

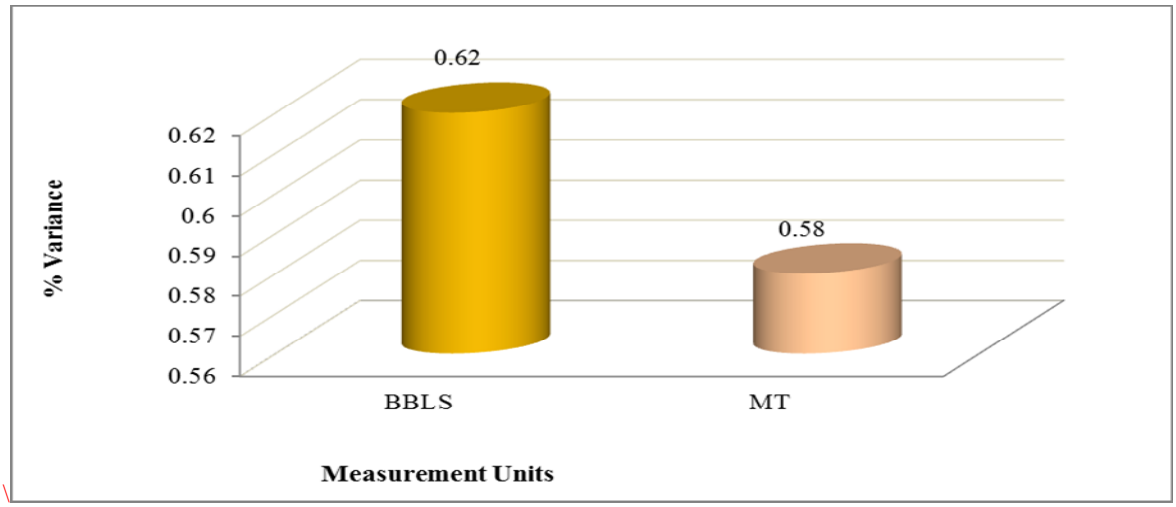


**Figure 5:** Inconsistency in W-K pipeline segment data presented in volume and the equivalent in weight.

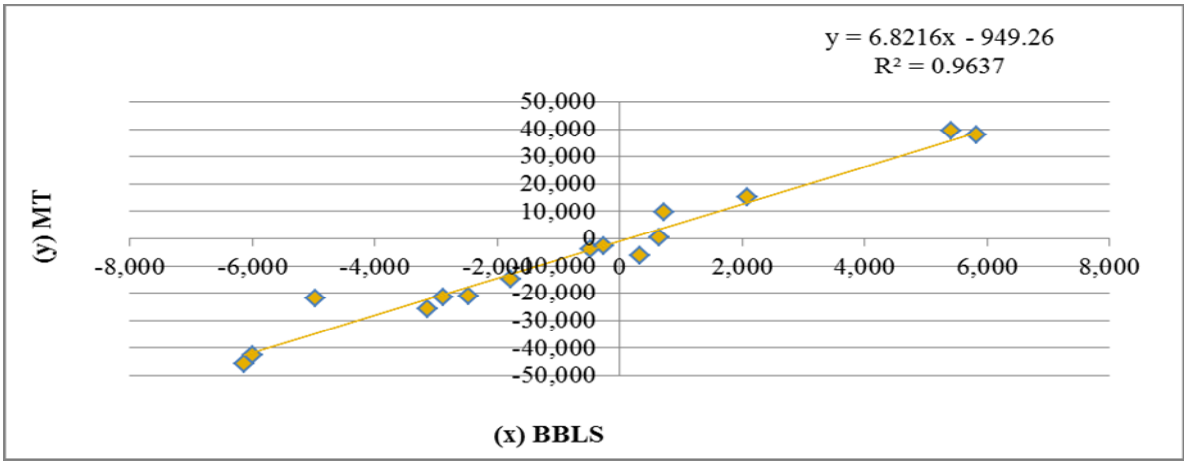


**Figure 6:** Plot of pumped and received difference in weight and volume (W-K segment)

### 3.1.2 SIMPLIEFIED PROCEDURE TO ENSURE THAT FIGURES PRESENTED IN VOLUME AND WEIGTH ARE CONSISTENT AND RELIABLE

For light oil, the oil industry conversion factor is in the range of 7.3 to 7.35. Therefore converting from barrels to metric tons requires that the figure in barrel be divided by the chosen factor. Alternatively, figure in barrel can be multiplied by the inverse of the same factor.

Using Table 3 as an example, the differences between the pumped and received were extracted and compared with observed factor with oil and gas industry accepted factor.

**Table 4**: Calculated field conversion factor using trimmed mean technique.

| MONTH/YEAR | CALCULATED DIFFERENCE | | CALCULATED FACTOR (BBLS/MT) | REARRANGED FACTORS | FACTORS TRIMMED BY 22% | TRIMMED MEAN (T) |
|---|---|---|---|---|---|---|
| | BBLS | MT | | | | |
| November, 2004 | 21,759 | 3,162 | 6.88 | 5.88 | Figures have been trimmed | |
| February, 2005 | 123,244 | 16,849 | 7.31 | 6.88 | | |
| March, 2005 | 278,298 | 27,583 | 10.09 | 7.15 | 7.15 | 7.15 |
| April, 2005 | 252,096 | 34,704 | 7.26 | 7.16 | 7.16 | 7.16 |
| May, 2005 | 312,112 | 42,496 | 7.34 | 7.21 | 7.21 | 7.21 |
| June, 2005 | 245,011 | 31,208 | 7.85 | 7.21 | 7.21 | 7.21 |
| July, 2005 | 417,081 | 56,147 | 7.43 | 7.22 | 7.22 | 7.22 |
| August, 2005 | 360,636 | 49,723 | 7.25 | 7.25 | 7.25 | 7.25 |
| September, 2005 | 109,939 | 14,826 | 7.42 | 7.26 | 7.26 | 7.26 |
| October, 2005 | 181,921 | 25,447 | 7.15 | 7.26 | 7.26 | 7.26 |
| November, 2005 | 361,109 | 49,732 | 7.26 | 7.31 | 7.31 | 7.31 |
| December, 2005 | 114,040 | 15,549 | 7.33 | 7.33 | 7.33 | 7.33 |
| January, 2008 | 76,382 | 9,810 | 7.79 | 7.34 | 7.34 | 7.34 |
| February, 2008 | 44,582 | 7,579 | 5.88 | 7.42 | 7.42 | 7.42 |
| March, 2008 | 675,615 | 93,757 | 7.21 | 7.43 | 7.43 | 7.43 |
| April, 2008 | 288,922 | 40,096 | 7.21 | 7.79 | 7.79 | 7.79 |

| | | | | | | |
|---|---|---|---|---|---|---|
| May, 2008 | 109,240 | 15,130 | 7.22 | 7.85 | Figures have been trimmed | **∑T = 102.34** |
| June, 2008 | 366,992 | 51,242 | 7.16 | 10.09 | | **T = 7.31** |

Table 5: Avoidable error between the two measured data and the equivalent in monetary terms

| TABLE | FIELD RAW DATA | | CORRECTED FIELD DATA USING 7.31 | | SPOTTED ERROR | AMOUNT | |
|---|---|---|---|---|---|---|---|
| | A (barrels) | B (mt) | A. (barrels) | (NGN) | A minus B (barrels) | (USD) | (NGN) |
| 1 | 58,094 | 18,061 | 58,094 | 132,026 | 73,932 | **3,553,172** | **1,279,141,891.00** |
| 2 | 4,186,215 | 565,420 | 4,186,215 | 4,133,220 | 52,995 | **2,546,940** | **916,898,292.00** |
| 3 | 103,390 | 13,069 | 103,390 | 95,534 | 7,856 | **377,559** | **135,921,370.00** |

### 3.2 DISCUSSION

**Effects of wrong conversion factors**

There were differences between the pumped and received figures. The established factor was compared with oil and gas industry accepted conversion factor. The implications of using erroneous conversion factors manifests during accounting processes. The performance of each pipeline segment was tabulated as pumped and received figures. The difference in pumped and received and the percent difference were calculated. From the analysis, it is clear that the field data presented in volume and its assumed equivalent in weight are not consistent, therefore they are not equal and uniform. Figure 1 has the percentage difference in volume and weight as 0.16% and 0.37% respectively, Figure 2, has the percentage difference in volume and weight as 9.5% and 9.46. Figure 3 has the percentage difference in volume and weight as 0.62% and 0.58%. It was observed that the error could be due to use of wrong specific gravities or conversion factors. The gap in percentage looks close, but when the economic value to the difference is presented, it becomes obvious that figures of this nature should be handled meticulously by professionals who understand the need for consistency.

For example, from Table 5, when the cost of the difference in weight and volume are calculated using the conversion factor of 7.31 (1mt is equal to 7.31 barrels), the difference in the two unified values gives the volume presented below.

When 1mt is equal to 7.31 barrels,

The figure 13,069 mt will be equivalent to 95,534 barrels (7.31 multiplied by 13,069).

Then 103,390 barrels minus 95,534 barrels gives 7,856 barrels.

Assuming price per barrel is $48.06,

Then 7,856 barrels will amount to $377,559.

iii Following the same calculation steps:

The monetary value for 73,932 barrels difference is about $3,553,172 while 52,995 barrels is also about $2,546,940. This same scenario can be applied to all pipeline segments where there is need to reconfirm the field data before use. The regression chart presented as figures 4, 5, and 6 were plotted to determine how close the figures are to the fitted liner relationship. R-squared ($R^2$) in the plot is known as coefficient of determination. It is the percentage of the response variable that is explained by a linear model. The coefficients of determination for the three plots are 0.9592, 0.9879 and 0.9637 respectively. Each coefficient explains all the variability or inconsistency of the collated field data around their mean. The following were discovered after the completion of this preliminary study:

There was inconsistency in the figures presented in volume and their equivalent in weight.

The errors could be due to use of wrong relative densities of conversion factor.

The cost implication is enormous as seen is Table 4.8.

The first discrepancy is 73,932 barrels which is equivalent to **$3,553,172 (N1, 279,141,891).**

The second is discrepancy is 52,995 barrels and is equivalent to **$2,546,940 (N916, 898,292).**

Thirdly the discrepancy from analyzed Table 4.3 is 7,856 barrels, giving **$377,559 (N135, 921, 37)**.

Successful rule of thumb to check the conversion was established as 7.31.

The value of the factor depends on the type of petroleum fluid. Note that the factor 7.31 is specifically for Escravos light.

What is important is to use the same procedure to arrive at a factor that will provide uniform result for any product irrespective of the unit being used.

It should be noted that a mini research carried out on Gasoline stock figures gave the model figure from metric tons to barrel is approximately as 8.434.

This means that for every volume pumped through the pipeline segments, the consistency of the figure can be checked confidently using the conversion that 1metric tons is equivalent 7.31 barrels. It has also been tested and proved.

Typically, in every batch pumping operation the field figures presented in volume and their equivalent in weight are not always consistent. Therefore there is need for every field collated data to pass through simple process check before the information can be transmitted for decision making. In this work, the model factor has been established.

The monetary value of the discrepancies on the selected segments are $3,553,172 (N1, 279,141,891), $3,553,172 (N1, 279,141,891) and 377,559 (N135, 921, 37) respectively. The huge amount can gradually put an organization out of operation.

**Notation**

Inconsistency in pipeline delivery figures presented in weight the equivalent in volume is established.

The factor for converting Escravos light crude oil from metric tons to barrel handily is 7.31.

## CONCLUSION

It is obvious that the figures declared in metric tons are not error free. The errors are due to use of wrong relative densities. To ensure best practices are followed, these errors must be corrected using the model. The application of the model will eliminate the ambiguities usually encountered during stock reconciliation. Also the final reports will stand the test of time at any international oil and gas stakeholders meeting.

## REFERENCES

**[1]** Andersen, A. (2000): "NASA 2000 Accountability Report; National Aeronautics and Space Administration", Indiana University. p. 1.

**[2]** Dandekar, A. Y. (2010): "Petroleum Reservoir Rock and Fluid Properties" 2nd ed.United States of America: Press Taylor & Francis Group. p. 38.

[3] Geisler, E. (2007): "Knowledge and knowledge Systems: Learning from the wonders of the mind. Illinois Institute of Technology", USA. New York: 191 publishing, Hershey. p. 9.

**[4]** Ghosal, S. K. and Datta, S. (2006): "Introduction to Chemical Engineering". 16th ed. New Delhi:

**[5]** Teta McGraw-Hill Publishing Company Limited. p. 42-43.

[6] Himmelblau, D. M. and Riggs, J. B., (2012): "Basic Principles and Calculations in Chemical Engineering", 6th ed. New York: Prentice-Hall of India. p. 12-25.

**[7]** Joel, O. F. and Udofia O. O. (2012): *Pipeline Vandalism in Nigeria: Recommended Best Practice of Checking the Menace, 36th Annual SPE International Technical Conference and Exhibition,* in Lagos-Nigeria, August 6-8, 2012.

**[8]** Speight, J. G. (2015): "Handbook of Petroleum Product Analysis: Chemical Analysis, A series of Monographs on Analytical Chemistry and its applications", 2nd ed. New Jersy: John Wiley. p. 4.

**[9]** Speight, J. G., (2014): The Chemistry and Technology of Petroleum, Chemical Industries/137. 5th ed. United States of America: CRC Press, Taylor & Francis Group. p. 34.

**[10]** Speight, J. G. and Ozum, B. (2009): "Petroleum Refining Processes", New York: Marcel Dekker Inc. p. 1.

**[11]** Wauquier, J. (1995): Petroleum Refining: Crude Oil, Petroleum Products, And Process Flowsheets. vol 1. France: Eds. Technip. p. 1.

**[12]** Wiehe, I. A. (2008): "Process Chemistry of Petroleum Macromolecules", 1st ed. United States of America: CRC Press Taylor & Francis Group. p. 24.

Appendix A-1: Observed Pumped and Received figures from Chevron-Escravos pipeline segment

| MONTH / YEAR | PUMPED | | RECEIVED | |
|---|---|---|---|---|
| | BBLS | MT | BBLS | MT |
| November, 2004 | 199,792 | 27,053 | 205,357 | 27,761 |
| February, 2005 | 1,380,385 | 187,446 | 1,373,007 | 186,100 |
| March, 2005 | 1,410,085 | 191,645 | 1,410,428 | 191,470 |
| April, 2005 | 1,426,544 | 193,774 | 1,426,763 | 193,755 |
| May, 2005 | 2,486,820 | 338,088 | 2,483,602 | 337,145 |
| June, 2005 | 2,665,159 | 362,721 | 2,610,846 | 354,591 |
| July, 2005 | 3,347,921 | 452,752 | 3,381,290 | 458,539 |
| August, 2005 | 2,108,852 | 287,043 | 2,109,448 | 286,321 |
| September, 2005 | 2,476,788 | 336,399 | 2,474,722 | 335,676 |

| | | | | |
|---|---|---|---|---|
| October, 2005 | 3,453,215 | 469,375 | 3,440,380 | 467,195 |
| November, 2005 | 1,582,189 | 215,408 | 1,584,563 | 215,133 |
| January, 2008 | 535,012 | 78,056 | 469,388 | 63,813 |
| February, 2008 | 2,307,981 | 315,217 | 2,364,316 | 322,975 |
| March, 2008 | 3,106,690 | 424,436 | 3,099,886 | 422,705 |
| April, 2008 | 2,539,624 | 346,977 | 2,534,396 | 345,240 |
| May, 2008 | 2,009,329 | 274,729 | 2,008,485 | 275,482 |
| June, 2008 | 2,918,255 | 398,013 | 2,919,670 | 397,170 |
| **TOTAL** | **35,954,641** | **4,899,132** | **35,896,547** | **4,881,071** |

Source: (PPMC, 2004 to 2008 monthly Stock Report.).

Appendix A-2: Pumped and received figures from Escravos - Warri pipeline segment

| **S/N** | **PUMPED** | | **RECEIVED** | |
|---|---|---|---|---|
| | **BBLS** | **MT** | **BBLS** | **MT** |
| November, 2004 | 375,183 | 50,667 | 353,424 | 47,505 |
| February, 2005 | 1,572,490 | 213,032 | 1,449,246 | 196,183 |
| March, 2005 | 1,819,607 | 236,927 | 1,541,309 | 209,344 |
| April, 2005 | 1,824,868 | 248,601 | 1,572,772 | 213,897 |
| May, 2005 | 2,437,331 | 330,939 | 2,125,219 | 288,443 |
| June, 2005 | 2,848,878 | 384,954 | 2,603,867 | 353,746 |
| July, 2005 | 3,031,081 | 410,912 | 2,614,000 | 354,765 |
| August, 2005 | 2,741,364 | 372,931 | 2,380,728 | 323,208 |
| September, 2005 | 3,105,529 | 422,189 | 2,995,590 | 407,363 |
| October, 2005 | 2,774,965 | 377,456 | 2,593,044 | 352,009 |
| November, 2005 | 3,049,100 | 415,493 | 2,687,991 | 365,761 |
| December, 2005 | 3,892,640 | 29,435 | 3,778,600 | 513,886 |
| January, 2008 | 707,570 | 96,220 | 783,952 | 106,030 |
| February, 2008 | 2,216,685 | 301,757 | 2,172,103 | 294,178 |
| March, 2008 | 3, 471,203 | 473,231 | 2 ,795,588 | 379,474 |
| April, 2008 | 2,242,581 | 305,677 | 1,953,659 | 265,581 |
| May, 2008 | 2,830,824 | 386,149 | 2,721,359 | 371,019 |
| June, 2008 | 3,100,599 | 422,235 | 2,733,607 | 370,993 |
| **TOTAL** | **44,042,498** | **5,978,805** | **39,856,058** | **5,413,385** |

Source: (PPMC, 2004 to 2008 monthly Stock Committee Report.).

Appendix A-3: Pumped and received figures from Warri- Kaduna pipeline segment.

| S/N | PUMPED | | RECEIVED | |
|---|---|---|---|---|
| | BBLS | MT | BBLS | MT |
| February, 2005 | 978,999 | 133,473 | 994,301 | 135,547 |
| March, 2005 | 1,638,362 | 224,449 | 1,616,824 | 221,578 |
| April, 2005 | 1,483,116 | 201,981 | 1,483,494 | 202,627 |
| May, 2005 | 1,203,146 | 163,252 | 1,199,361 | 162,783 |
| June, 2005 | 1,191,858 | 162,003 | 1,170,838 | 159,539 |
| July, 2005 | 1,573,820 | 213,839 | 1,583,587 | 214,554 |
| August, 2005 | 836,290 | 113,824 | 793,693 | 107,837 |
| September, 2005 | 1,329,121 | 180,070 | 1,314,185 | 178,298 |
| October, 2005 | 1,226,447 | 167,423 | 1,265,756 | 172,835 |
| November, 2005 | 958,025 | 130,325 | 955,175 | 130,068 |
| December, 2005 | 1,222,658 | 166,062 | 1,196,762 | 162,930 |
| March, 2008 | 1,059,336 | 143,967 | 1,037,460 | 138,989 |
| April, 2008 | 833,264 | 112,347 | 871,270 | 118,167 |
| May, 2008 | 432,618 | 57,742 | 387,129 | 51,614 |
| June, 2008 | 750,167 | 100,680 | 744,002 | 101,002 |
| **TOTAL** | **16,717,227** | **2,271,437** | **16,613,837** | **2,258,368** |

Source: (PPMC, 2004 to 2008 monthly Stock Committee Report.).