THE KEY TO MINIMIZE MISCALCULATION OF OIL/CONDENSATE - QAS (QUANTITY ACCOUNTING SYSTEM) BY APPLYING ASTM PROVISIONS

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ABSTRACT

The Petroleum Industry does not only consist of exploration and exploitation activities, but there are other activities that are also important, namely lifting activities. The lifting activity is one of the transfer/shipping activities from upstream (Producer) to downstream (Buyer). One of the lifting activities is the calculation of the amount of oil/condensate, which is a calculation of the calculation and reporting of oil/condensate that is applied in managing the distribution of oil/condensate production from the block station to the point of sale. The importance of this calculation system is due to the amount of lifting that will be reported to the state. This needs to be done well to avoid the wrong amount of value. ASTM (American Society for Testing and Materials) is an international organization that develops and publishes technical standards for various materials, products, systems and services. The lifting job based on the conditions established by ASTM can minimize the possibility of errors in calculation of QAS (Quantity Accounting System), in this case specifically for fluid level measurements in tanks, temperature measurements, methods and techniques for measuring the number of samples, proving job, laboratory analysis (such as Density, BS&W, etc), and the methods that must be used (Flow Meter or Meter Tank Gauging) for QAS input. This paper is made using reference activities that happen in lifting points in Riau Province, North Sumatra Province, and Aceh Province. It is expected to provide more understanding of the necessary of applying the ASTM provisions to lifting activities.

Keywords: QAS, ASTM, Meter Tank Gauging, Density, BS&W

LIFTING

Lifting is the activity of transferring a number of crude oil/condensate volumes at the point of delivery. Usually the amount of crude oil/condensate (COC) to be transferred is called the lifting nomination. Lifting must have good planning, in order to:
1. Optimizing Lifting so that stock and Over/Under Lifting positions can be avoided.
2. Facilitate the Lifting coordination process for scheduling shipments and planning of distribution to refineries.
3. As a basis of calculating (estimated volume) for export licenses.
4. As a basis for preparing estimates of achievement of lifting until the end of the year

The procedure for submitting COC is carried out in accordance with the technical procedures of the surrender operation for each point of submission that was compiled and agreed upon by the government institution, the buyer and the Contractor of the Cooperation Contract (KKKS).

In this paper, several examples of lifting points are taken in North Sumatra Area. There are several lifting terminals / Floating Storage Oil (FSO) in the northern part of Sumatra, as follow:
1. Dumai Terminal, Riau Province, operated by the Chevron KKKS
2. Terminal Arun, Aceh Province, operated by the PHE NSO NSB KKKS
3. Pangkalan Susu Terminal, North Sumatra Province operated by Pertamina EP KKKS
4. Buatan Terminal, Riau Province, operated by Pertamina EP KKKS
5. Ladinda FSO, Riau Province operated by the EMP Malacca Strait KKKS

Because this lifting activity is very important, it is necessary to do a standard measurement procedure to minimize any errors in calculating the amount of crude oil/condensate to be transferred (QAS).

ASTM

ASTM is known as the American Society for Testing and Materials, where it is a technical standard made for various materials, products, systems and services. The ASTM organization
itself is located in West Conshohocken, Pennsylvania, about 5 mi (8.0 km) northwest of Philadelphia, this organization was founded in 1898 as the International America Association for standard testing and materials.

In the United States, the ASTM standard has been adopted, through the establishment or reference, in many federal, state and city regulations. Other governments also use ASTM as a standard reference, even for the sale of all toys in the United States must comply with the standard ASTM F-963 (standard consumer safety specifications for toys).

This paper will discuss the application of several ASTM’s related to Lifting that has been applied in the lifting terminal / FSO in northern Sumatra, including:

• ASTM D 1085; related to level measurement methods for Crude Oil and Crude Oil products
• ASTM D 1086; related methods from temperature measurements for Crude Oil and Crude Oil products the sounding
• ASTM D 4057; related to manual sampling measurement methods for Crude Oil and Crude Oil products
• ASTM D 1298; related to the method of measuring Density, Relative Density or Gravity API for Crude Oil and Crude Oil products
• ASTM D 4007; related to the method of measuring Water and Sediment for crude oil using the Centrifuge method.

All ASTM above are very important in order to obtain an accurate value regarding fluid level measurement, average temperature, API Gravity and the percentage value of basic water and sediment (BS&W) from crude oil. These values will be used to acquire the net volume value from petroleum in standard conditions (60°F).

ASTM D 1085

This ASTM describes the provisions for measuring oil levels and other liquid production that is placed in tank, container, and others. There are 2 basic measurements, namely innage and outage, where innage is a measurement of the depth of liquid in a tank measured from the surface of the liquid to the tank bottom (a fix datum plate) while an outage is a measurement of the distance from the reference point to the surface of the liquid in tank. This measurement is very important, if in the calculation of the volume of Oil/Condensate is done without using a flow meter.

On the left side show the difference between innage and outage method, while on the right side display the sounding tape that is used for both methods.

![Figure 1. The Differences Between Innage and Outage Method](image)

Figure 1. The Differences Between Innage and Outage Method

In all terminals / FSO in northern Sumatra using sounding tape of Innage type, but in Ladinda FSO, they use outage method of measurement to determine the level of the liquid. There are several considerations regarding the use of outage measurement methods. Ladinda FSO uses the outage method, considering the location is offshore, which is different from the other one that is a land tank (the liquid is not steady). And for notification, the way to measure the height of liquid in Dumai terminal is not common, the sounding tape is not stretched to the bottom plate (measuring table), due to sludge’s height reason.

![Figure 2. Sounding Tape, that is used as a tool to measure the liquid level](image)

Figure 2. Sounding Tape, that is used as a tool to measure the liquid level

ASTM D 1086

This provision explains how to determine the temperature in petroleum liquids, the accuracy of the measured temperature is very important for calculating the standard volume at 60 degrees F. In ASTM D 1086, 4 types of thermometers are recommended, namely:

• Cup Case
• Flushing Case
• Armored Case
• Air Jacketed Thermometer
All types of thermometers have specifications that are resistant to corrosion. For the type of land terminal or floating storage oil that has a fixed or floating roof tank, a cup case and flushing case type is recommended. Above are the example that are used in Dumai terminal and Pangkalan Susu terminal.

For the measurement of temperature, using spot method is used, with details as below:

| DEPTH OF LIQUID | MINIMUM NUMBER OF TEMPERATURE MEASUREMENTS | MEASUREMENT LEVELS |
|-----------------|------------------------------------------|--------------------|
| More than 15 ft. | 3                                        | 3 ft below top surface of liquid, middle of liquid, and 3 ft above bottom surface of liquid. |
| 10 to 15 ft.     | 2                                        | 3 ft below to surface of liquid and 3 ft above bottom surface of liquid. |
| Less than 10 ft. | 1                                        | Middle of liquid. |

And the minimum detail of the immersion time is related to the viscosity value as below:

| LIQUID | MINIMUM IMMERSION TIME, MIN |
|--------|-----------------------------|
| Crude, gasoline, naphtha, kerosine, gas oil and other oils of Saybolt Universal Viscosity less than 100 sec at 100 F | 5 |
| Crude, light lubricating, fuel, and other oils of Saybolt Universal viscosity above 100 sec at 100 F and below 170 sec at 210 F | 15 |
| Crude, heavy lubricating, cylinder, gear, residual, and other oils of Saybolt Universal viscosity above 170 sec at 210 F | 30 |

Noted:
100 sec Saybolt Universal = 20 Centepoise ; 170 sec Saybolt Universal = ± 30 Centepoise ; 170 Sec Saybolt Universal = 40 Centepoise.

Implementation in all terminals / FSO of northern Sumatran have adopted the above procedure and the standard thermometer type specified in ASTM D 1086.
ASTM D 4057

ASTM D 4057 regulates a representative crude oil sampling procedure. Basically, there are 2 types of sampling job, taking samples directly from the tank (manual sampling) and sampling that comes from the liquid flowing in the pipe or called Automatic sample. For manual sampling there are several types, as follows in Table 3.

In ASTM D 4057 it is stipulated that crude oil sampling is required to use Automatic Sampling, or recommended manual sampling. The recommendations given are:

- **Spot Sampling**
  Where is done by looking at the capacity or height of the liquid in the tank, with the following details in Table 4. There are 2 types of tools used for this sampling, namely: bottle / beaker spot sampling and core type sampling thief.

- **Running or all level sampling**
  Sampling is done by taking liquids at all heights

- **Tap sampling**
  Sampling is done on taps sampling in the tank section

- **Bottom sampling**
  Sampling is done using a core type sampling thief and usually used to take water samples at the bottom of the tank.

| Table 3. Several Types of Manual Sampling |
|------------------------------------------|
| 1. All levels sample                     | 14. Lower sample |
| 2. Boring sample                         | 15. Middle sample |
| 3. Bottom sample                         | 16. Multiple tank composite sample |
| 4. Bottom water sample                   | 17. Outlet sample |
| 5. Clearance sample                      | 18. Representative sample |
| 6. Composite sample                      | 19. Running sample |
| 7. Core sample                           | 20. Spot sample |
| 8. Dipper sample                         | 21. Surface sample |
| 9. Drain sample                          | 22. Tank composite sample |
| 10. Floating roof                        | 23. Tap sample |

| Table 4. Required Samples of Spot Sampling |
|--------------------------------------------|
| Required Samples                           |
| Tank Capacity/Liquid Level                |
| Upper | Middle | Lower |
|-----------------|-----------------|-----------------|
| Tank capacity less than or equal to 159 m³ (1 000 bbls) | X | X | X |
| Tank capacity greater than 159 m³ (1 000 bbls) | X | X | X |
| 3 m (10 ft) < Level ≤ 4.5 m (15 ft) | X | X | X |
| Level > 4.5 m (15 ft) | X | X | X |

The application of sampling to terminals / FSO in northern Sumatra already follow the regulation that is set in ASTM D 4057, such as Dumai terminal that have adopted the Automatic sampling system for each lifting and backing up activity by taking manual sampling by spot sampling using core type sampling thief. Arun, Pangkalan Susu, Buatan Terminals and Ladinda FSO used manual sampling using running all level sampling with bottle / beaker sampling.

Figure 4. Bottle/Beaker Sampling That Is Used In Pangkalan Susu Terminal.
ASTM D 1298

D 1298 is a method of measuring Density, specific gravity (SG) and API gravity value from petroleum itself in laboratory using a hydrometer. Those value are very important parameters in the calculation of QAS (conversion from the observed form becomes a standard calculation at 60°F). This measurement is carried out using several laboratory instruments such as a measuring cup, water bath (heater), thermometer and hydrometer. The first step is making the temperature of the sample stable, not too hot which causes the loss of light components, or not too cold which causes the sample becomes waxy. For this type of waxy oil, try to keep the temperature 9°C above the pour point or 3°C above from the cloud point.

in the Pangkalan Susu, Buatan terminal, and Ladinda FSO, all samples are not reheated, the value is read directly from the hydrometer. For Dumai terminal each sample taken either Sumatera Light Crude (SLC) or Dumai Crude Oil (DCO) is heated to a temperature of 120°F to get a sample in liquid enough condition and be easy to analyze. Whereas for Arun terminals there is a slight difference in treatment / procedures, this is seen from the condensate sample taken from the tank directly into the refrigerator. After a while later it was taken out and immediately read the API gravity value. For details in Figure 5 below.

Figure 5. The tools that is used of the test in Dumai Terminal for Density, SG, and API Gravity value

ASTM D 4007

Standard 4007 is a measurement of basic water and sediment (BS&W) in crude oil using a centrifuge, ASTM is not accurate enough to measure the value of sediment and water, but is quite efficient and does not take much time. ASTM D 4006 and D 473 are very accurate measurement procedures to obtain water and sediment values.

The value of BS&W is one of all parameters in crude oil which is very important to generate the final net value of crude petroleum volume (gross).

Some of the tools and materials used in this test are:
• Centrifuge
• Centrifuge tubes
• Water bath
• Pipettes
• Toluene (ISO 5272) saturated 60±3°C C₆H₅CH₃
• Demulsifier

The mechanism or stage of the experiment is as follows:
• Fill 2 centrifuge tubes each with 50 ml of sample and then add 50 ± 0.05 mL of toluene which has been saturated, and add 0.2 mL demulsifier using a pipette.
• Shake by turning the centrifuge tube for 10 times.
• Heat the two centrifuge tubes in a bath with a temperature of 60±3°C (140±5°F) for 15 minutes.
• Place the tube into a centrifuge and rotate it for 10 minutes with a minimum number of relative centrifugal force is 600. The centrifuge must have a temperature of 60±3°C (140±5°F).
• After the rotation, then read BS&W value on the tube like the Table 5 below. And sum up the value.

Table 5. BS&W Value On The Tube

| Tube 1 | Tube 2 | Total Percent Water and Sediment % (%)
|--------|--------|-------------------------------------|
| No visible water and sediment | No visible water and sediment | 0.00 |
| 0.025 | 0.025 | 0.00 |
| 0.05 | 0.05 | 0.10 |
| 0.075 | 0.075 | 0.15 |
| 0.10 | 0.10 | 0.20 |
| 0.10 | 0.10 | 0.25 |

In reading the results it is necessary to pay attention to the tolerance limit value between the two tube values as below:

Table 6. The Tolerance Limit Value Between The Two Tube Values
If the reading value is greater than the tolerance limit above, then the test is categorized as a failure.

### Table 1. Substitution Volumes and Tolerance

| Range, mL | Substitution, mL | Volume Tolerance, mL |
|-----------|------------------|----------------------|
| 0 to 3    | 0.05             | ±0.02                |
| Above 0.1 to 0.3 | 0.05             | ±0.01                |
| Above 0.3 to 0.5 | 0.05             | ±0.01                |
| Above 0.5 to 1.0 | 0.10             | ±0.05                |
| Above 1.0 to 2.0 | 0.10             | ±0.10                |
| Above 2.0 to 3.0 | 0.20             | ±0.10                |
| Above 3.0 to 5.0 | 0.50             | ±0.20                |
| Above 5.0 to 10.0 | 1.00             | ±0.50                |
| Above 10.0 to 25.0 | 5.00             | ±1.00                |
| Above 25.0 to 100.0 | 25.00            | ±1.00                |

For the Dumai, Pangkalan Susu, Buatan, terminal and Ladinda FSO have adopted this ASTM 4007 method well and but for Arun terminal do not yet have the facilities to accommodate BS&W analysis is due to the type of oil in the form of condensate which has zero tendency for BS&W values. **Figure 6** shows the tools that exist in Dumai Terminal for BS&W analysis test.

### Conclusions

1. The importance of applying the ASTM standard to ensure that no errors will happen in QAS calculations, there are 5 ASTM that are important to be applied, namely ASTM D 1085, D 1086, D 4057, D 4007, and D 1298.
2. All terminals and FSO in the Northern Sumatra Area have implemented all ASTM standards properly, although some are not appropriate due to consideration of the type of crude oil. With detailed comparisons such as attachments.
3. In applying the ASTM standard, each terminal and FSO are equipped with an SOP which is made as a technical guide for the implementation of Lifting.

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## Attachment

| ASTM D 1085 | Dumai Terminal | Arun Terminal | Pangkalan Terminal | Buatan Terminal | Ladinda FSO |
|-------------|----------------|---------------|-------------------|----------------|-------------|
| Well applied using Innage Sounding Tape, but the outage method for the measurement | Well Applied using Innage Sounding Tape, the Innage Method for the measurement | Well Applied using Innage Sounding Tape, the Innage Method for the measurement | Well Applied using Innage Sounding Tape, the Innage Method for the measurement | Well Applied using Innage Sounding Tape, the Innage Method for the measurement | Well Applied using Innage Sounding Tape, the Innage Method for the measurement |
| ASTM D 1086 | Wood Cup Case Thermometer Applied properly | Flushing Case Thermometer Applied properly | Flushing Case Thermometer Applied properly | Flushing Case Thermometer Applied properly | Flushing Case Thermometer Applied properly |
| Using Automatic Sampling for the priority, Manual sampling is Well applied using Core Type Sampling Thief | Well Applied using Bottle / Beaker Sampling | Well Applied using Bottle / Beaker Sampling | Well Applied using Bottle / Beaker Sampling | Well Applied using Bottle / Beaker Sampling | Well Applied using Bottle / Beaker Sampling |
| ASTM D 1298 | Applied properly note: heated to a temperature of 120°F | Slightly different from ASTM, the sample cooled in the refrigerator until it freezes | Applied properly in accordance with ASTM | Applied properly in accordance with ASTM | Applied properly in accordance with ASTM |
| ASTM D 4007 | Applied properly in accordance with ASTM | No analysis | Applied properly in accordance with ASTM | Applied properly in accordance with ASTM | Applied properly in accordance with ASTM |