Safe and efficient fuel handling at tank terminals

Relevant for: fuel tank farms, fuel terminals, fuel depots

Economical, safe and efficient trading on the basis of harmonized and verified product specifications of fuels is of vital importance for tank terminals that deal with these essential goods of our daily life. Digital measurement technology is ideally suited to meet these requirements.

1 A challenging business

1.1 The specifics of tank terminals

Often located near the coast and close to major cities or refineries, there are around 6,400 tank terminals worldwide. Their total storage capacity of more than 1 billion cubic meters is continuously served by ship, road and rail tankers or pipelines. While the facilities can only contain one, but also up to several hundred tanks, they all have in common that the quantity and quality of the incoming and outgoing goods is directly related to the economic success of these versatile and busy places.

In addition to safety during the delivery of new fuels and the shipping of stored fuels, stable product quality during storage and the avoidance of unintentional mixing and product loss are further important tasks of a tank farm, which are supported, controlled and secured by digital measuring devices.

1.2 The importance of regulations

Regardless of whether it is diesel, gasoline, jet fuel, or ethanol for blending, compliance with internationally recognized product specifications (e.g. ASTM or EN) and local equivalents derived from them is of utmost importance for fuel trade at tank terminals where legal regulations need to be fulfilled and complaints have to be avoided. Each individual petroleum fuel product is precisely characterized by a set of clearly defined properties, which in turn can be characterized using measuring technology.

Achieving these target properties is not only important for trading fuels, but of course also for the safe and proper operation of the intended engine.

The following tables showcase a selection of fuel properties for diesel according to EN 590 and jet fuel according to ASTM D1655:

Diesel		
Product specification EN 590		EN/ISO test method
Density @ 15 °C	820 – 845 kg/m³	EN ISO 12185
Viscosity @ 40 °C	2 – 4.5 mm²/s	EN 16896
Flash point	> 55 °C	EN ISO 2719
CFPP	Class 0 - 5	EN 116

Table 1: Selected diesel properties according to EN

Jet fuel		
Product specification ASTM D1655		ASTM test method
Density @ 15 °C	775 – 840 kg/m³	D4052
Viscosity @ -20 °C	< 8 mm²/s	D7042
Flash point	> 38 °C	D56
Existent gum	< 7 mg/100 mL	D381

Table 2: Selected jet fuel properties according to ASTM

1.3 The need for measuring technology

Anton Paar devices for checking fuel quality include checks on the density, viscosity, flash point, fire point, distillation range, oxidation stability, gum content, cold flow properties, and purity of fuel products.

Fast and accurate measurements of these parameters according to clearly defined test methods enable short reaction times and help to minimize the risk of financial losses and delays – all in all contributing to efficient, profitable and safe tank farm operations.

They also help tank terminals rise to the challenge of stricter legal regulations regarding emissions and environmental impact and the resulting increase in testing and monitoring of fuels whenever they change hands.

2 Supervised fuel movement

Wherever quick decisions are needed prior loading or unloading operations, the versatile measuring devices from Anton Paar are ready for operation not only in the traditional lab, but also directly at the pipeline or close the tank in the field.

2.1 Product identification and quantification

One of the fastest and most reliable ways to correctly identify a certain type of fuel product is by means of digital density measurement based on the oscillating U-tube principle.

2.1.1 On-site density measurements in hazardous areas (Ex-zone 1)

Anton Paar's portable and intrinsically safe DMA 35 Ex Petrol quickly measures density or specific gravity on-site even in hazardous areas directly at the fuel terminal and in full compliance with ASTM D7777 and IP 559. Samples are measured either upon delivery of new fuels for characterization or when sampled from different layers of storage tanks, to determine the different layers in the tank. Thanks to its intrinsically safe design – certified according to ATEX and IECEx regulations – it is ready for these high safety requirements and provides by far the fastest, safest and most robust way of on-site fuel product identification.

Density measurements are carried out at ambient temperature. All fuel-relevant quantities, such as °API, Density or specific gravity (SG) for specific product groups (e.g. diesel) and common reference temperatures used for trade (e.g. 20 °C or 60 °F) are calculated automatically according to ASTM D1250.

In contrast to manual hydrometers, the instrument is virtually unbreakable and eliminates any potential user error.

Figure 1: DMA 35 Ex Petrol

2.1.2 Multiproduct pipeline – product detection

Currently the most common method to ensure the correct transfer of the products to the corresponding tanks at the tank terminal is run-time based. Due to variations in flow speed, volumetric changes or pressure drops even a precise calculation cannot assure an exact product cut like it can be guaranteed with product detection with a process density sensor.

An accurate detection of products and interfaces is only possible with a density instrument that is mounted directly into the pipeline to prevent filling of tanks with wrong or unintentionally mixed product. By continuously measuring the density before switching the valve the operator is able to ensure that the correct product is filled into the correct tank at any given time.

The highly accurate process density sensor L-Dens 7300 from Anton Paar is able to detect differences in product density within only a second. If the measured density is in a specified range, the valve can be switched immediately. This fast and precise product detection ensures minimized product loss and waste quantity which in turn directly affects a tank farm´s profitability.

2.1.3 Volume to mass conversion

Mass is one of the fundamental units for trading liquids. But many transfer points in the petroleum industry are equipped with volume meters. Therefore, density is needed to calculate the mass of the transferred products from the volume.

Because of the huge amount of product which is transferred between parties, a small measuring error can cause a major financial loss. The financial loss is a linear function of the error of the density measurement! An error of a tenth percent of the density measurement will be a deviation of a tenth percent in the accounting. Because of the huge

amount of product this can be a huge amount of money.

In addition, a highly accurate and continuous density measurement prevents the operator of a tank farm - besides a loss of profit - to be confronted with legal regulations against black marketing where deviations in the mass balance of tank farms have to be kept below a certain limit.

The combination of a highly accurate process density meter L-Dens 7400 and a volume flow meter assures an optimum of mass balance determination, required for tight financial control of custody transfer points. The combination of continuous density and volume measurement is a good alternative to direct mass flow measurement because of competitive pricing, higher density accuracy and lower integration effort as well as the possibility to upgrade existing flow meters.

If a modification of a plant is not possible, the accuracy of the mass calculation can be easily improved by using the highly accurate laboratory density meter DMA 4501 or DMA 5001 from Anton Paar.

Figure 2: L-Dens 7400 Version Ex d

2.2 Product classification

Fuel trade is based on internationally accepted consensus in the form of product specifications which in turn refer to a defined set of test methods for each of the required parameters. All parameters from these product specifications need to be verified upon delivery and prior pumping of a fuel product into a tank. Density is one of the important parameters from such product specifications. While portable density meters are used on-site and process density sensors are used online for quick product identification, the verification of product specifications calls for the more precise test method ASTM D4052 (refer to Table 1 and Table 2).

DMA 1001 and DMA 4101/4501 are benchtop density meters that comply with this test method.

Figure 3: DMA 4101, DMA 1001

The compact DMA 1001 can be placed on-board a mobile lab or near the sampling location due to its compact design requiring only 70% of space compared to other density meters and stable measuring technology 100% unaffected by external influences. The Intelligent condition monitoring system gives a warning and recommended action if the instrument´s environmental conditions are not in the ideal range. And, the ventilation-free temperature control avoids suction of contaminated air or dust into the housing and electronics and thus ensures a long working life. DMA 1001 is engineered for field operation and ensures 100 % uptime and stable results. This minimizes maintenance efforts and downtimes and maximizes productivity.

The DMA 4101/4501/5001 with an accuracy up to the 6th digit (DMA 5001) by far outperforms the requirements of ASTM D4052 for situations where unmatched accuracy is all that counts: an example for this is volume-to-mass conversion for account settlement. These laboratory density meters are the benchmark for any fuel density measurement application and can be equipped with fully automatic sample changers for highest sample throughputs.

Figure 4: SVM 3001

In addition to the most accurate density measurement technology, the SVM Viscometer series adds another unique measurement sensor in a single instrument: viscosity according to ASTM D7042 and density according to ASTM D4052 are measured on the same sample and at the same time. In addition, SVM features a wide range for viscosity, temperature and density, enabling measurement of different fuel samples (e.g. jet fuel, diesel, heavy fuel) with a single measuring cell.

2.2.1 Checking the authenticity of fuels to avoid adulteration

When buying fuels from suppliers you want to make sure that you receive the right product and not an adulterated fuel mixed with cheap components as this would lower the quality of the fuel and damage the engines and the relationship with your end customers. With Anton Paar's compact Raman spectrometers you can quickly verify the quality of incoming goods within seconds directly at the warehouse. The portable instruments are used without any sample preparation, chemicals, or consumables, thereby reducing waste and providing a quick and low-cost approach to raw material identification.

Figure 5: Cora 5001

3 Safe fuel storage

It is absolutely crucial for producers and consumers of petroleum fuels to guarantee high quality and to maintain this during storage and transportation. One major criterion to ensure the fuel properties do not change until used is the sufficient oxidation stability. Of course, also any kind of contamination needs to be excluded as well. All existing test methods to check for these relevant characteristics of the fuels have the same goal – safe application of the unchanged product.

3.1 Storage conditions

3.1.1 Identifying contaminations during storage and transport

Gum is a nonvolatile residue that is left after evaporation of aircraft fuels, motor gasoline, and other volatile distillates. The amount of gum present is an indicator for contamination of the fuel by higher boiling oils or particulate matter and generally reflects poor fuel handling practices or bad storage conditions.

Therefore, precautions must be taken during transportation and storage in order to avoid contamination of fuels due to particles and other impurities.

Gum also appears due to oxidation in the presence of air or by chemical reactions of fuel components like unsaturated hydrocarbons. This is the reason why stabilizing agents, such as oxidation inhibitors, are added in order to increase the fuel stability.

Figure 6: GUM

Anton Paar's gum tester is used to determine the amount of gum in fuels at specific test conditions in accordance with ASTM D381, ISO 6246, JIS K 2261, IP 131, and IP 540.

The instrument provides the highest level of safety and time savings of up to 10 minutes per measurement thanks to simultaneous determinations with its multi-function head.

3.1.2 Finding the optimal storage conditions with accelerated aging

There are various standard test methods depending on the fuel type to determine the oxidation stability. However, the RapidOxy 100 Fuel is the optimal choice as an all-in-one bench-top instrument.

No matter whether gasoline or diesel from B0 – B100 needs to be tested, Anton Paar's unique RSSOT (Rapid Small-Scale Oxidation Test) instrument will run through the determination fully automatically according to the respective standard test method. Highest efficiency and throughput are guaranteed by measurements that are up to 20 times faster than traditional procedures while only 5 mL of sample are required.

Figure 7: RapidOxy 100 Fuel

3.1.3 Reduce the loss due to evaporation

The main source for hydrocarbon emission is the exhaust gases of vehicles. However, volatile hydrocarbons are also released into the environment from tanks of cars when refueling and during transportation and storage as a result of evaporation. Losses of gasoline when moving from producer to consumer can even climb up to 2%. Distillation analysis uncovers at which temperatures fuels start to evaporate and form vapors which in turn helps to reduce evaporation losses.

Furthermore, to find the correct classification and storage conditions each fuel that is released into the market must be classified according to its boiling behavior. This helps to know how to safely handle the corresponding product in the lab as well as during storage and transportation.

Figure 8: Diana 700

Diana 700 is the ideal solution for automatically performing high-precision distillation range analysis at atmospheric pressure. The instrument automates manual handling steps during the measurement setup to provide maximum support and helps untrained users with a step-by-step guide through the procedure that is necessary to start a distillation.

Using the highly efficient Peltier technology, Diana 700 enables a fast switch between different ASTM D86 distillation groups and reaches the required temperatures in less than five minutes to increase the efficiency of the testing personnel.

3.2 Safety classification

For storage, transport, and handling of flammable or combustible liquids, such as fuels, the flash point is one of the most important parameters used in terms of safety. The flash point is used to define the hazard classification of liquids and provides important information for fuel product specifications. Depending on the product, e.g. jet fuel or diesel, different methods are suitable to determine the flash point.

Flash point of diesel and jet fuel		
Product specification	Flash point method	Suitable device
ASTM D975 (Diesel)	ASTM D93	PMA 500 / PMA 5
ASTM D1655 (Jet fuel)	ASTM D56	TAG 4
Jet fuel according to ISO and IP standards	ISO 13736 / IP 170	ABA 4
EN 590 (Diesel)	ISO 2719	PMA 500 / PMA 5

Table 3: Selected product specifications and the associated flash point methods.

Anton Paar's PMA 500 is the state of the art Pensky-Martens flash point tester that complies with ASTM D93 and ISO 2719, among other standards, suitable for diesel flash point determination.

Its new and unique ceramic-coated electric igniter will save operational costs as its lifetime is more than 10 times higher compared to a traditional igniter. The unchallenged cooling technology saves up to 10% of the measurement time and the well-done design reduces cleaning efforts to further save time and avoid faulty measurements.

Figure 9: PMA 500

Both ABA 4 as well as TAG 4 are perfectly suited for flash point measurements of jet fuels according to ASTM D56, ISO 13736, and IP 170 within a temperature range of -30 °C to 110 °C. The efficient Peltier cooling technology ensures that temperatures below ambient temperature are achieved quickly. The innovative multidetector combines temperature measurement and flash point detection in one device, assuring full compliance to the standard requirements.

Figure 10: ABA 4

Contact Anton Paar GmbH

Tel: +43 316 257-0

info@anton-paar.com | www.anton-paar.com