Coping with Standard Procedures for Density Measurement

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Parallel to the refining process, which evolved from a simple batch distillation to a complex process, the range as well as the quality of petroleum products has been steadily increasing. Standard organisations have therefore evolved recommendations for measuring techniques to determine essential properties of petroleum products that governments often rely on.

Density as a function of pressure and temperature is probably the most important property of petroleum fluids, whether liquid or gaseous, affecting production, processing as well as transport and storage.

Reliability for QC labs

In contrast to using a hydrometer as described in ASTM D1298, a digital density meter is more accurate and easier to operate. For the characterisation of liquid petroleum distillates and viscous oils the standard test method to determine density and relative density using a digital density meter is described in ASTM method D4052. For crude oils that are dark in colour ASTM method D5002 is used.

Based on a reliable and accurate density measurement (refer to fig. 1) a modern density meter offers features that are also indispensable for complying with standard test methods:

- Density values automatically converted into relevant quantities, namely specific gravity (SG), API values in respect to ASTM D1250 (standard guide for use of the petroleum measurement tables)
- Live camera image (or inspection window) ensuring bubble-free filling that at best is assisted by the instrument's advanced analysis to detect filling errors
- Possibility to check the purity of the reagents used by determining the density and comparing it to the target value
- Temperature stability and one adjustment for the whole temperature range only as can be achieved by a built-in reference oscillator

Out in the fields

In some cases it makes sense not to transport samples into a lab, but to determine the density of products directly from drums or tankers. Suitable for field applications, ASTM method D7777 describes the determination of density, relative density or API gravity of liquid petroleum products using portable digital density meters. As with laboratory instruments, hand-held density meters also have to provide reliable density readings that are automatically converted into prescribed quantities such as API gravity or relative density at reference temperatures. Bubble-free filling is ensured via an inspection window. Due to harsh environmental conditions in the field the instrumentation must have a high level of robustness. This requirement is met by digital density meters - especially in comparison to the traditional measuring methods according to D287 and D1298. Further, well-designed instruments come with a special housing that is resistant to petrochemicals and an Ex marking certificate (fig.3) for the use in hazardous areas, e.g. II 2 G Ex ib IIC T4.

Heavy ends

Density and relative density of samples like asphalt, bitumen, asphalt cement and soft tar pitches, the heavy ends of the vacuum distillation, are determined according to ASTM D70. This standard method requires a pycnometer and is not only time-consuming (min. 80 min per sample) and cumbersome, but also requires a lot of practice in order to achieve moderate precision: First the flask has to be partially filled with the heated sample without touching the sides above the final level. Then the pycnometer is completely filled with water and the determined weights

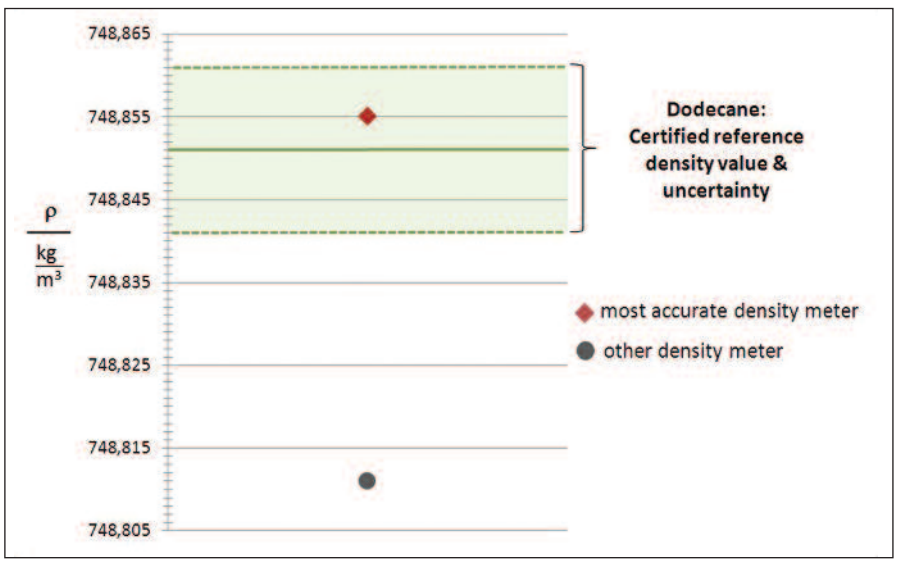

Figure 1: Density values for a petroleum-like standard reference liquid (dodecane) obtained with two different density meters measured at 20 °C

are used to calculate the density. In this field digital density measurement is also the faster and easier method that does not depend on the operator's skills and provides more repeatable results. However, for this application specially designed density meters are needed, e.g. a U-tube made of Hastelloy can withstand temperatures higher than 100 °C (up to 200 °C) and therefore keeps samples liquid inside the measuring chamber.

Figure 2: A modern density meter offers relevant features and complies with ASTM D4052

Figure 3: Instruments suitable for use within hazardous areas carry an Ex marking

Conclusion

Modern digital density measurement nowadays is indispensable in the petroleum industry as density is not only used as a quality criterion for products, but also used in the size calculation and design of e.g. pumps, valves, gravity decanters, pipes and tanks as well as in the determination of thermodynamic properties. While density meters primarily have to provide accurate measurement performance a suitable density meter design depends on special needs: Reflecting the sample's nature, whether gaseous, liquid, high-melting or viscous, the U-tube can either be made of glass or Hastelloy while environmental demands and regulations require benchtop or portable density meters.

References

(1) D1298: Standard Test Method for Density, Relative Density, or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method

(2) D4052: Density, Relative Density and API Gravity of Liquids by Digital Density Meter

(3) D5002: Density and Relative Density of Crude Oils by Digital Density Analyzer

(4) D1250: Standard Guide for Use of the Petroleum Measurement Tables

(5) D7777: Density, Relative Density, or PII Gravity of Liquid Petroleum by Portable Digital Density Meter

(6) Pat.No. AT 399051

(7) D70: Specific Gravity and Density of Semi-Solid Bituminous Materials