VERIFICATION / CALIBRATION OF DEVICES USED IN STATIC LIQUID MEASUREMENTS

Robert Maze (Presented by Andrew Biddle)

SGS North America Inc.
Oil, Gas, and Chemicals Services

The purpose of verifying or calibrating liquid measurement devices is to ensure the accuracy of quantities being reported. With millions of dollars at stake, fractions of an inch or tenths of a degree Fahrenheit can make quite an impact to bottom line. At its most basic, the static (as opposed to dynamic, the use of meters) quantity determination of liquid hydrocarbons is generally obtained by measuring the depth of the liquid in a storage tank and obtaining a representative temperature. Through the use of volume tables and volume expansion factors the quantity at a standard temperature can be stated.

Several factors play an important role in quantity determination. Some of the factors are product density, the presence of free water, ambient temperature, tank construction (including roof design, stilling well design, stability of the tank bottom, etc.), as well as method of creation of the tank capacity tables. Additional factors come into play when measuring static liquids on board marine vessels.

Another key factor is the accuracy of the devices used to measure the volume and temperature.

The two basic main types of devices used for the static measurement of hydrocarbon liquids consist of a gauging device used to determine the depth of the liquid and a temperature measuring device. Automatic or remote measurement devices are available and are verified through the use of manual equipment.

Manual gauging devices are either a hand held steel tape or portable electronic device. Electronic devices are designed for open, restricted, or closed applications. Restricted or closed systems are used in conjunction with a vapour control valve. A specially designed type of measuring stick has been designed for the use on rail cars.

Manual temperature devices are either glass stem thermometers or portable electronic thermometers. Portable electronic thermometers can be stand alone or can be built into an electronic gauging device.

There are different international standards bodies which publish the specifications for the design and verification of calibration of these devices. For the purpose of this paper we will focus on the requirements as set forth by the American Petroleum Institute (API).

Calibration vs. Verification

As defined by the International Bureau of Weights and Measures (BIPM) calibration is "Operation that, under specified conditions, in a first step, establishes a relation between the quantity values with measurement uncertainties provided by measurement standards and corresponding indications with associated measurement and, in a second step, uses this information to establish a relation for obtaining a measurement result from an indication." Or in simpler terms the documented exact differences between a measurement device and a known standard.

The BIPM further states that "Calibration should not be confused with adjustment of a measuring system … or with verification of calibration."

ISO 9000:2015 defines verification as "Confirmation, through the provision of objective evidence, that specified requirements have been fulfilled." In the use of static measurement devices this would mean that any errors or differences found in a measurement device did not exceed the tolerances allowed by the procedure being followed.

Gauge Tapes

The design and verification of manual gauge tapes are defined in the API Manual of Petroleum Measurement Standards Chapter 3 Section 1A – Standard Practice for the Manual Gauging of Petroleum and Petroleum Products.

A hand held tape consists of one continuous length of steel tape of sufficient length for the height of the tank to be gauged. It is mounted in a frame or case with a reel and crank. The free end is fitted with a locking device to which a weighted bob can be attached. A portable electronic device has a housing to contain electronic components and read outs connected by a tape

to an electronic sensing device which gives an audible signal when the surface of the liquid is contacted. Both are verified in the same manner.

New tapes shall be inspected the entire length for proper application of the numerals and increments. Working tapes shall be inspected daily or before each use for kinks or wear of the locking device and the bob eye and bob tip.

If used for custody transfer purposes working tapes must be verified before initial use and at least annually there after. Verification consists of a comparison to a reference tape (master tape) traceable to the National Institute of Standards and Technology (NIST) or other weights and measures standards authorities. Master tapes will be recertified every five years or more frequent with regular use.

The verification of a working tape consists of a comparison against a certified reference tape at regular intervals throughout the working length of the tape at intervals not to exceed 15 feet or 5 meters. Both tapes are placed under tension, usually 10 pounds, and shall not exceed a difference of greater than +/- 2mm (1/16 inch) for any comparison point. (Figure 1)

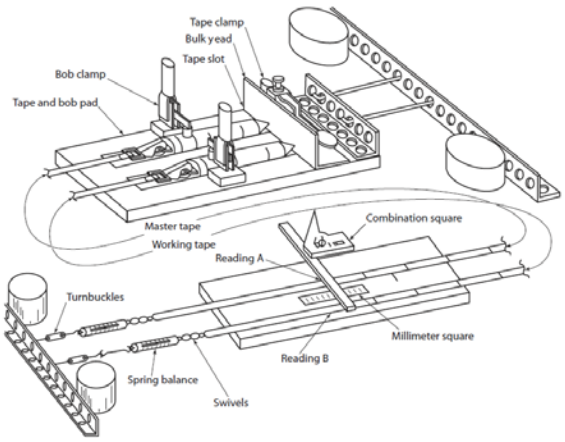

Figure 1 Tape and Bob Comparison

Rail Car "Quick Stick"

Measurement devices used in determining the quantity of rail cars when full are frequently referred to as "Quick Sticks" due to how quickly a measurement can be obtained. They are subject to some of the same verification requirements as other measuring devices.

The basic design of a "Quick Stick" is a ruler and a series of right angles. Provided the ruler is accurate and the device is undamaged they are verified before each use and once per year there after. Daily field inspections are made to look for damage.

Temperature Measuring Devices

The calibration and verification of temperature measuring devices are defined in the API Manual of Petroleum Measurement Standards Chapter 7 – Temperature Determination.

Portable Electronic Thermometers (PET) are subject to annual calibration, monthly verification, and daily field checks.

Annual calibration is to be performed, before initial use, after repair, or if the monthly verification is found to be out of tolerance. Calibration is performed at three points, the mid point and near the ends of the range of the PET. Ranges vary from manufacturer to manufacturer with the greatest range being -50°F to 400F. The narrowest range is -40°F to 180°F.

The following tolerances apply to all calibrations

0 – 200°F +/- 0.2°F
0 – 100°C +/- 0.1°C
>200°F +/- 0.5°F
>100°C +/- 0.3°C

The reference thermometer used for the range of 0-200°F (0-100°C) shall be traceable to the National Institute of Standards and Technology (NIST) or other weights and measures standards authorities shall have scale marks at no greater than every 0.4°F (0.2°C)

The reference thermometer used for the range of > 200°F (100°C) shall be traceable to the National Institute of Standards and Technology (NIST) or other weights and measures standards authorities shall have scale marks at no greater than every 1°F (0.6°C).

The following inspections should take place before each use and during calibration.

- Is the junction between the cable and probe free of mechanical damage?
- Is the cable insulation free of cuts, breaks or abrasions?
- Is the grounding cable free of damage?
- Is the housing free of cracks or damage?

Monthly verification is performed identical to the annual calibration except the PET is checked at only two points, near the ends of its range. If either point exceeds the stated tolerance the device must be removed from service, repaired as necessary and calibrated at three points.

Field checks - Before each use, or once per day (whichever is less frequent), PETs should be spot checked by comparing the ambient reading against an ASTM glass stem thermometer in liquid. If the reading differs by more than +/- 0.25°C (0.5°F), the portable electronic thermometer should be re-calibrated before it is used for custody transfer.

Thermometers

Glass thermometers shall conform to ASTM E1, Standard Specification for ASTM Liquid-in-Glass Thermometers, specifications where applicable. Thermometers include:

- Complete-immersion, the entire thermometer is exposed to the temperature being measured. ASTM does not have a specification for complete-immersion thermometers.
- Partial-immersion, designed to indicate temperature correctly when the bulb and a specific portion of the stem is exposed to the temperature being measured.
- Total-immersion, a liquid in glass thermometer designed to indicate the temperature correctly when just the part of the thermometer containing the liquid is exposed to the temperature being measured.

Verification is performed prior to initial use and at least once per year afterwards. It consists of a comparison to a reference thermometer traceable to the National Institute of Standards and Technology (NIST), or an equivalent thermometer of traceable accuracy. It is typically perform at three points representing 10%, 50%, and 90% of the temperature range in which it is expected to be used.

Thermometers must be handled with care and inspected for formation of an insulating film, loss of pigment from the engrave scale and mercury separation.

Considering the current price of crude oil the accuracy of the equipment used to measure the quantities bought and sold becomes an important factor. An error of ¼” in a typical 250,000 bbl tank could represent $10,000 and an error of 0.5°F on that same tank (if full) could represent $5,000.