Paper 22

API Draft Standard - Measurement of Liquid Hydrocarbons by Ultrasonic Flow Meters using Transit Time Technology

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Draft API standard

“Measurement of Liquid Hydrocarbons by Ultrasonic Flowmeters Using Transit Time Technology”

History & Background

At the agenda of API meetings always time is reserved for new emerging measurement technologies. About eight years ago, in 1996, the flow measurement technology of ultrasonic flowmeters was introduced. Based on the technological information together with the experience accumulated with flowmeters in use by a number of European users, API decided this development formed a sufficient basis to start an Ultrasonic Task Group.
The assignment the task group received was to investigate the possibility of creating a standard that describes the use of ultrasonic flowmeters in custody transfer applications on liquid hydrocarbon products.

Ultrasonic Task Group

The formation of the Ultrasonic Task Group proved to be an easy task, as there was much interest in joining the new Task Force among API members. The developments of the ultrasonic flowmeters already created a lot of interest and much was expected of this new flowmeter technology. A team consisting of 12 members was formed. According to good API practices, the team consisted partly of representatives coming from the oil industry, the end-users, and partly of participants coming from the manufacturers’ side, both American and European suppliers.

As a first step existing test data on ultrasonic flowmeters was gathered, in order to generate sufficient proof on the viability of the ultrasonic technology for use of the ultrasonic flowmeters in custody transfer applications of liquid hydrocarbons.
The API committee decided not to go in the direction of laboratory tests, but to perform field tests instead. The main reason for this was that the Task Force questioned whether laboratory tests would generate representative conditions occurring in practice. API had the experiences that in practice additional issues can come up which could later give rise to unforeseen problems. In addition API standards are application orientated and therefore practical aspects are highly valued.

Definition of Practical Test Sites

Three test sites among end-users of the Task Force were defined:

- The first test site concerned a pipeline pumping station. Various refined products including gasoline and petrol were transported via this pipeline.
- The second test site was an application on LPG.
- The third test site comprised of a test loop at the intake of a refinery. This location gave the option to measure a wide range of products from naphtha to crude oils.

For each test site a test protocol was defined. The data collection was automated. The measurements were always traceable to a locally available (ball or piston) prover.

Based on the first, encouraging, results the Ultrasonic Task Group decided to start writing the text for the draft standard in parallel to the tests being performed. The API standard on turbine meters (chapter 5.8) was used as the basis for the API standard on ultrasonic flowmeters and adapted wherever necessary for ultrasonic flowmeters.

Formation of the Ultrasonic Working Group

After sufficient data was collected and reviewed, the task group judged that the ultrasonic flow measurement technology indeed proved to be a viable technology for custody transfer applications of liquid hydrocarbon products.

The next step was to transform the status task group into a working group. The primary goal of the working group was to finish writing the API standard on ultrasonic flowmeters. However, this required the acknowledgement of all members of the API Committee of Liquid Measurement (COLM) to subscribe the conclusion of the Ultrasonic Task Group that the ultrasonic flow measurement was a viable technology for the custody transfer liquid hydrocarbon measurements. At the API fall meeting of 2000 the measurement results and conclusions were presented to the COLM. The opinion of the task force proved to be unanimously shared by the 50 members of the COLM.

In the next year of 2001 the Ultrasonic Working Group was mainly occupied with the contents of the standard text. During monthly meetings the text for the standard was grafted. At the 2002 API spring meeting the final work on the text was finished and the text for the standard was presented for voting by the COLM members.

Ultrasonic Draft Standard

Although already there was much test and application data available to grant the work for a standard, this information could not yield a ‘full’ standard right away. The procedure within the API is such that before receiving the status of a ‘full’ standard it first receives the status of a ‘draft’ standard. The idea is to gather more experience and test data over the first two years of the existence of the draft standard. Provided of course these test results are positive the evolution into a ‘full’ standard can take place.

In order to allow for the gathering of sufficient experience on the presented technology, a draft standard has the same legal status as a ‘full’ standard and should, as such, be treated in a similar same way.

Following the API procedure the standard was consequently proposed as a draft standard to the COLM. Unfortunately, the draft standard did not pass the first COLM vote. The API procedure for accepting new (or modifications to) standards requires there are no negative votes. Since there were some negative votes on the proposed draft standard, at first a number of issues had to be resolved.

The draft standard was presented to the COLM for a second time in September 2002. The text of the standard was adapted to incorporate improvements resulting from the discussion raised by the negative votes.

This time the API standard on liquid ultrasonic flowmeters passed the COLM vote. The draft standard 'Measurement Of Liquid Hydrocarbons by Ultrasonic Flowmeters Using Transit Time Technology' was now officially published by API.

Content of the Ultrasonic Draft Standard

The draft standard covers all issues concerning the
- installation,
- operation and
- maintenance

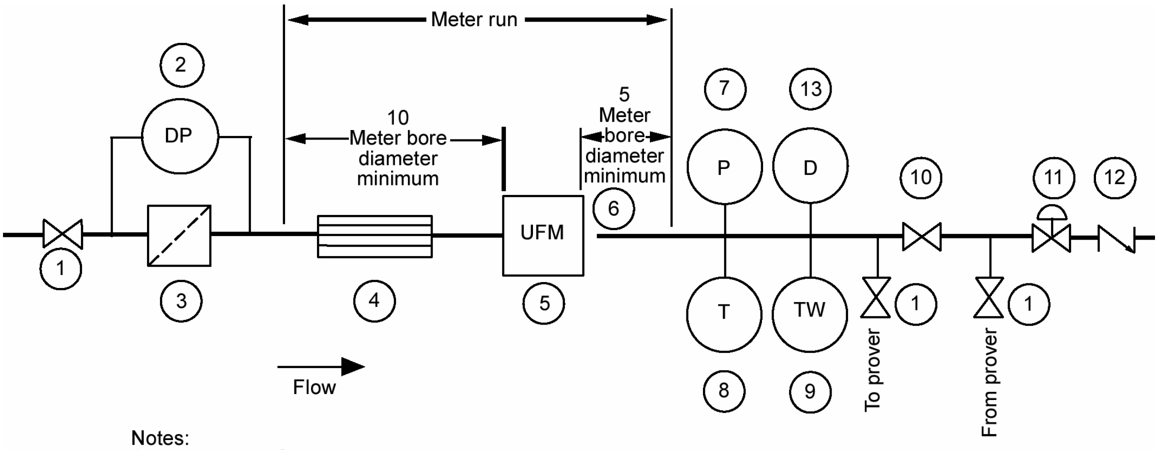
of ultrasonic flowmeters.

First of all, the API draft standard is a practical standard of nature designed to give (new) users of ultrasonic flowmeters guidance in how to use the technology in practice.
Secondly, the standard only covers a 2-path (or more) spool piece type flowmeter with fixed sensors.

Installation Conditions

Within the above mentioned framework quite a large part of the draft standard is dedicated to the installation of ultrasonic flowmeters.

An ultrasonic flowmeter is always defined in the standard as part of a 'meter run'. A meter run either consists of 20 diameters (D) of straight upstream pipe and 5 D downstream or of 10 D upstream including a straightening device and 5 D downstream. An ISO type tube bundle was used during the tests. The meter run must remain unperturbed and all disturbances are defined outside of the meter run.
The work performed by the Ultrasonic Working Group did not comprise of flow perturbation testing. The draft standard indicates that should more data become available this should be included in the standard.



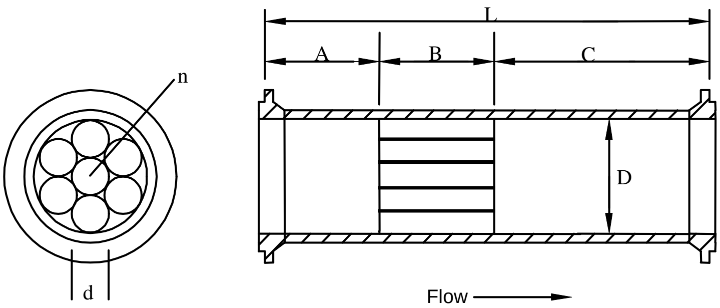
Notes:
1. Block valve, if required.
2. Differential pressure device, if required.
3. Filter strainer and/or vapor eliminator (if required) for each meter or whole station.
4. Straightner assembly per Figure 2. or 20 pipe diameters without straightning assembly.
5. Ultrasonic Flowmeter.
6. Straight pipe.
7. Pressure measurement device.
8. Temperature measurement device.
9. Temperature test well.
10. Positive shutoff double block-and-bleed valve.
11. Control valve, if required.
12. Check valve, if required.
13. Densitometer, if required.

Note: All sections of line that may be blocked between valves should have provisions for pressure relief (preferably not installed between the meter and the prover).

Figure 1 - Schematic Diagram of Typical UFM Installation.

Temperature, Pressure and Density Sensors

Disturbances caused by temperature, pressure and density sensors are described and should be, as is the case for control valves, always located downstream of the meter run. For bi-directional flow these sensors should be placed upstream in the less frequently used condition and additionally a positive flow and a reverse flow meter factor have to be established.



Note: This figure shows assemblies installed upstream of the meter. Downstream of the meter, 5D minimum of straight pipe should be used.

L = overall length of straightener assembly (≥ 10D).
A = length of upstream plenum (2D-3D).
B = length of tube of vane-type straightening element (2D-3D).
C = length of downstream plenum (≥ 5D).
D = nominal diameter of meter.
n = number of individual tubes or vanes (≥ 4).
d = nominal diameter of individual tubes (D/d ≥ 10).

Figure 2--Example of Flow-Conditioning Assembly With Straightening Element

Use of Strainers

Interesting to note is that the API standard indicates that strainers are not required for the ultrasonic flowmeters, but that they may be required for other components (for example pumps, provers) in the system.

Gas, Flashing and Cavitation

The API standard indicates that the gas and/or vapour content needs to be sufficiently low and hints to proper installation and gas eliminators in order to reduce the measurement error. Also reference to specific manufacturer's guidelines is being made.
For applications that run close to the vapour pressure of the measured liquid a formula is incorporated that gives a guideline for the required minimum back pressure to avoid flashing in the ultrasonic flowmeter itself.

Proving

API advocates on-site proving for custody transfer flow measurement devices. The current draft ultrasonic standard forms no exception to that, although for allocation measurements, laboratory proving is acceptable.

In the current API standard on proving (Ch. 4.8.2.1) repeatability under stable flow conditions is used as a criterion (5 consecutive runs within a repeatability band of 0,05 %). For ultrasonic flowmeters, given their non-inertia measuring principle, this criterion can be hard to meet, especially when small volume provers are used. The draft standard acknowledges this fact and points to Ch. 4.8 table A1 of the Manual of Petroleum Measurement Standards.

In chapter 4.8 the 5 run 0,05 % repeatability criterion is translated into an ±0,027% uncertainty (95% confidence level). With the acceptance of an uncertainty criterion on the established meter factor, a different proving method can be introduced. This means that, analogue to a method presented at the North Sea Flow Measurement Workshop in 1999, now more than 5 proving runs can be taken to generate a meter factor within ±0,027 % uncertainty limits.
For this purpose the draft ultrasonic standard has included table A1 of Ch. 4.8 as appendix B. By following this appendix, measurement results that have a higher repeatability (than the 0,05% in 5 runs) can still be compliant to the ±0,027 % uncertainty when more measurements are taken. An example is given that 5 runs within a band of 0,05% and e.g. 10 runs within a band of 0,12% both have ±0,027% uncertainty on the calculated meter factor.

In practice this means that when small prover volumes are used, more runs may need to be taken, but that results with comparable uncertainty levels can be obtained. In essence a small prover volume is turned into a bigger proof volume by the increase of the number of meter runs that is used to derive the meter factor.

Operation

Update of Meter Factors

In the operation part of the standard practical issues with respect to how to handle the derived meter factors over time and where to input new meter factors are covered. As the meter factor can both be changed in the ultrasonic electronics and in the tertiary (flow computer) electronics, API prefers meter factors be changed in the tertiary equipment. This is mainly because of the audit trail requirements (Ch. 21.2) that normally are met by the tertiary equipment and are not integrated in the ultrasonic flowmeter electronics.

Zeroing

With respect to zeroing, API follows the recommendations of the manufacturers (based on test experiences) that ultrasonic flowmeters do not need (re-) zeroing.

Future Developments

With the existence of a API draft standard on ultrasonic flowmeters, the number of applications in which these flowmeters are used increases. An example of which is given by the acceptance of ultrasonic flowmeters by the Bureau of Customs and Border Protection (formerly known as the U.S. Customs Service).

Based on this growing experience the Ultrasonic Working Group gave itself a goal to have a 'full' standard completed by fall 2004. This means work has been started to incorporate

- remarks and improvements as suggested by the COLM members,
- and more information on gas and water in oil content,

and to further investigate installation conditions.

Conclusion

The introduction of a new measurement principle in an API standard is not a sinecure. Even with steady progress it has taken 8 years to get to the point where we are now and it will require one more year to get to a 'full' standard. However, looking back on the amount of work that has been performed within the time frame, the process could not, and should not, be speeded up, as when doing so the quality of the content of the standard could be compromised.

Acceptance of the work done by the API by other standardising organisations (e.g. ISO, OIML, AGA), and vice versa, provides a means of introducing new measurement principles on a worldwide scale in a shorter timeframe without compromising the quality of the content. Given the pace of current technological developments the conclusion has to be that the future lies in co-operation!

References

[1] Paper presented at the North Sea Flow Measurement Workshop, a workshop arranged by NFOGM & TUV-NEL

Note that this reference was not part of the original paper, but has been added subsequently to make the paper searchable in Google Scholar.