# Some Practical Considerations in Measuring Crude Oil

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Mechanization is as much the "order of the day" in the petroleum industry as in any other. Unlike many other commodities, however, crude oil, by its hetreogeneous nature, presents some very unique problems in measurement. This is especially true in the oil-field close to the wellhead -- the source of supply. Temperature, time, pressure, composition, amount of agitation, and several other factors have a very real bearing on the problem of accurately measuring crude oil. The following remarks will have to do generally with the problems involved in the field.

There are two basic methods of measuring crude oil now in general use - manual and mechanical.

The time honored manual method involves the visual reading of differential scale levels in a suitable tank. In this method a calibrated (strapped) tank is required and the levels are usually obtained by means of a graduated tape and plumb-bob. It is pointless to recount the many chances for gross error that are inherent with this rather crude method. The only wonder is that the industry has been content with it for so long.

Mechanical measuring or gauging involves the use of meters. There are many ideas for meters based on many principles. Currently, however, meters are of two basic types; the so-called positive displacement type and the volumeteric type. Strictly, both terms are misnomers because both depend upon a positive displacement and both are actually volumeteric. By common useage the term positive displacement meter is understood to mean one that depends upon velocity of the measured fluid to actuate the metering means. The term volumeteric meter has come to mean one that depends upon the cyclic accumulation, isolation, and discharge of the measured fluid. Both types naturally have advantages and disadvantages. Comparatively the P.D. type meters, by themselves, have the advantage of being more compact. They take up less space and generally weigh less than the volumeteric types. They are of course, automatic and they provide a more nearly continuous rate of discharge. P. D. Meters also have several advantages. They have closely machined parts in contact with the metered fluid. They are therefore vulnerable to corrosion and erosion, which can appreciably alter the volumeteric characteristics and can cause excessive "slippage" and friction in the moving parts. Furthermore the deposition of foreign material inside the metering chambers is another serious problem in P.D. meter accuracy. The passage of solids, such as sand, with the fluid, detracts from their accuracy.

P. D. Meters require fairly uniform velocity for optimum accuracy. This usually requires a system of surge tanks. Entrained gas will also actuate the meter and, of course, will reflect an incorrect total of liquid passed.

For the above reasons and others, P. D. Meters must be "proven" periodically. The "proving" means are generally of the volumeteric type. Furthermore, because of the above reasons and others, the maintenance cost may be rather high.

As indicated by the previous definition, volumeteric type meters alternately accumulate, isolate, discharge, and count the cycles of the measured known volumes of liquid.

Volumeteric type meters generally have a small but adequate space above the upper calibration level to dispose of entrapped gas and a similar space below the lower calibration level to catch entrapped solids. This more nearly assures that the predetermined volume will measure liquid only.

In volumeteric type meters there are generally no close tolerance parts in contact with the metered liquid except valve trim. Compared with P. D. Meters, the deposition of foreign material inside the vessel is relatively not so serious a problem because of the larger increment volumes handled by the volumeteric types. Variations in speed of metering and pressure have very little effect upon the accuracy of volumeteric meters within rather wide ranges of variation.

Volumeteric Meters also are entirely automatic in operation. The volume dumped each cycle can be visibly checked. Furthermore, the records of other information such as gas volume and pressure recordings provide ready means for cross checking on the total meter accuracy. Volumeteric Meters may therefore be their own "proving" meters. Because there are virtually no close tolerance parts in contact with the metered liquid maintainenance and upkeep cost are relatively very low.

Due to the simple external design of controls and adjustments of most volumeteric type meters, the operating personnel or switcher is capable of operating maintenance. Similar to any new equipment introduced into the industry, acceptance by the operating personnel is a factor of time.

Another advantage of the volumeteric type lies in the fact that gravity flow systems may be used when there are suitable means available for actuating the valves.

Like any other piece of equipment, volumeteric type meters also have their disadvantages. They have greater weight and require more space than the P.D. Meters alone without surge tanks, proving meter, etc.

Internal depositions of foreign material such as paraffin, asphalt, and the like naturally reduce the volumeteric accuracy. However, it is easy to apply any of the several internal coating which inhibit the deposition of such substances.

There are several factors involved in the design of volumeteric type Meters in addition to the standard code characteristics. Among them are shape, pilot, pilot actuating means, motor valves and internal coatings.

In shape, volumeteric type meters are of two general designs; seraphin-neck vessels and cylindrical vessels.

Proponents of the seraphin-neck design claim greater accuracy: apparently basing their contention on the familiar restricted stem of a chemist's pipette. If this is the basis of contention, the the similarity is false because without a preferential throttling means (which the chemist uses) to slow down the flow of liquid into and out of the vessel as the liquid enters the seraphin-necks it is difficult to keep from "overshooting" the mark.

Actually, regardless of the cross section area of the vessel at the level marks, the subtended volume in one shape can be just as accurate as any other provided the level control means is sufficiently sensitive. In any event, the accuracy of either type presently available is far greater than old style normal gauging.

The pilot and the pilot actuating means are the real "guts" of the Meter.

There are many excellent pilot actuating means. Various types include liquid pressure head, torque rod and torque tube, buoyancy mass, and positive float types. All have merits as well as disadvantages depending somewhat upon the particular service conditions.

Regardless of type, the actuating means should be simple and as nearly trouble free as possible. It should not be affected by vibration and mild shock and it should not be unduly affected by the deposition of foreign material.

In a similar manner, pilot valves vary widely in design and principle. A good pilot should first of all be accurate and dependable. It should be sensitive to minute changes in the liquid level and it must maintain its sensitivity over long time periods, whether constantly active or relatively inactive. Its repeating characteristics should be without question.

It must be extremely simple to adjust and the adjustment means should not be delicate to handle. It should be as nearly trouble-free as possible both from the standpoint of operators and operation. For good meter control the pilot should provide true snap action. In addition, where the pilot controls an inlet and an outlet valve simultaneously, it should operate the valves so that for an instant, at least, the entrapped liquid is isolated from the inlet and outlet lines at the same time. This is of course to prevent any "slippage" past the meter.

Good motor valves are necessary supplements to good pilots and actuating means. In normal motor service a good valve should be of the full-open full-closed type.

Either two motor valves are used; one in the inlet and one in the outlet; or one three-way motor valve is employed. When two one way valves are used, each on the inlet and outlet, it is extremely easy to ascertain a malfunction of either while the meter is in operation. By isolating the working components into one unit, visual inspection will determine a malfunction. It is difficult to determine leakage within a threeway valve during operation. The correct operation of the valves are extremely important in obtaining accuracy of measurement. The threeway valve has one advantage in that both inlet and outlet to the meter cannot be open at the same time. On the other hand for the most precise metering, such a three-way valve should be made so that both inlet and outlet ports can be closed at the same time.

In metering crude oil the ever present emulsion problem is of much concern. This problem is of great magnitude when sale of crude is paid on the basis of measured volume. Simply speaking BS&W generally has no market value. Many designs and units of manufacture known as samplers are on the market. The function of this equipment is to eject and accumulate minute quantities of fluid metered and by several methods determine a BS&W percentage of the total volume. A dissertation on the merits of sampling would be rather lengthy, but briefly touching the subject, obtaining the largest number of sample unit volumes per time has proven to be successful with water cut up to 50%. Methods are available whereby three phase separation, water, oil and gas, is accomplished, and each product metered. The metering of pipeline crude oil is accomplished in this method by proper heat applied in the three phase separator. This heat is generated by electricity or gas, since the practical application is for small volumes such as one well, and the BTU requirement is accordingly small.

There is one other problem in metering "raw" crude oil regardless of the method used and that is "flash factor". "Flash" is a factor of increasing importance where very high pressures and high gravity crude are involved. There is often a great difference between the volume of liquid measured at high pressure and the ultimate quantity of weathered "pipe line" oil in the stock tanks.

At least one satisfactory solution to this problem has been developed. A small accurately measured quantity (4000 cc) of the fluid is taken and the contents are weathered for a definite time or until the entrapped liquid level reaches equilibrium. This can be observed through a sight glass. A scale along side the sight glass is calibrated to read directly in percent of loss. The instrument is designed for very accurate reading inasmuch as each drop of one percent is indicated by almost one inch on the scale. Actual use of the "Flash Bomb" is simple and practical for comingling, multi-well testing, and other applications of automation. The determination of shrinkage factor is another tool to reach higher accuracy in volume measurement.

In view of the above discussion, it is not surprising that the established trend in the industry is away from the old manual tank gauging methods. Mechanical methods have completed their trial period and have amply demonstrated their superior value even to their most severe critics. It is also gratifying that the tendency is toward an even greater acceptance of automation with an ultimate goal of completely automatic operation.

Much has been said and is being done about automatic custody transfer in which the crude is produced, treated, separated, metered, and delivered to the pipeline with complete automatic equipment. Obviously, the advantages are legion. The particular stumbling block, as yet not completely surmounted, is largely a matter of education -- education of the company employees, both producer and buyer -- education of the royalty owners, and education of the regulatory bodies.

The final step will undoubtedly be a complete telemetering system for collecting, transmitting, tabulating, and evaluating all of the required information developed in a completely automatic system. Means are already at hand for all parts of the complex job.

Tomorrow, our friend the switcher will "work" his tour in a swivel chair.