Revisiting Measurement Technologies

MULTI-JET VS. POSITIVE DISPLACEMENT METERS IN 1996

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At the 1985 AWWA conference, one of this article's authors presented a comparison of the two residential metering technologies, positive displacement (PD) and multi-jet. In the ensuing decade, operational changes in the industry have impacted the two technologies. Extensive life testing of all water meter technologies has now demonstrated that high-quality examples of either technology have service lives greatly exceeding the useful utility lives of water meters.

The key phrase in the above is "high-quality examples of either technology." In comparing technologies, one must avoid basing comparisons on aberrational quality differences due to manufacturing methods. To eliminate this potential error in any technology comparison, only the best designs of each technology should be evaluated against another technology. Products designed with the same technology can be compared against each other to assess quality.

It is inevitable in a competitive market that manufacturers promote the features of their product relative to others. Quite often, the "facts" become obscured in such presentations, victims to marketing "puffery." This may not simply be a case of misrepresentation. It is often the case that when someone finds a piece of evidence to support his position, he fails to realize that the world has changed, and his "evidence" has become obsolete.

In comparing multi-jet and positive displacement measurement technologies, in 1985, value judgments (what level of performance at what price) tended to influence the evaluation. In 1985, multi-jet meters were believed to hold a cost advantage compared to positive displacement meters. Modem plastic molding techniques permit the internal measuring components of PD meters to be molded-to-size, just as are the internals of multi-jet meters. This change has eliminated the historical cost disadvantage of PD technology relative to multi-jet meters.

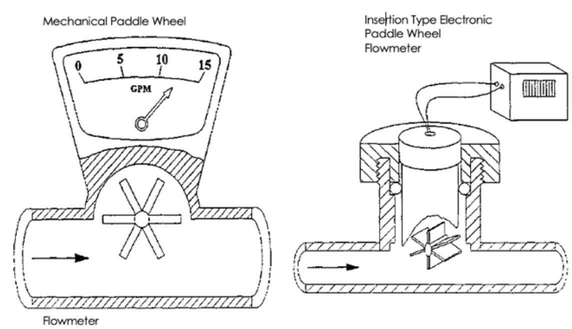
We wish first to dispel the notion that predominant use of multi-jet meters outside the United States somehow can be dismissed as attributable to a choice of price over accuracy. In the highly industrialized, quality-conscious countries of Europe, including Germany and Switzerland, where high-quality PD meters are manufactured for industrial liquids, and in very wealthy nations with severe water shortages and extremely high water production cost (middle Eastern nations) and where multi-jet meters sell for more than twice their U.S. prices, multi-jet meters are the preferred technology for water measurement.

Before proceeding further, terminology needs to be clarified. Multi-jet meters are not "paddle-wheel" meters. Paddlewheel meters see only a portion of the flow. Examples include some single-jet meters and insertion paddlewheel meters. (Figure 1) Multi-jet meters see all of the flow through a meter.

Next, the measuring element in a multi-jet meter is a rotor or impeller. As water flows through a multi-jet meter, the water flows through the precision converging orifices of the measuring chamber and causes the impeller to turn. The first multi-jet meter designs introduced to the U.S. lacked the engineered orifices of today's designs; in early cases, the orifices were drilled holes that caused water to "jet" against the impeller in a center-dominated-velocity profile. That is no longer the case. The orifices of today's multi-jet meter measuring chambers direct the water in a carefully engineered flow profile against the impeller, eliminating the adverse effects that "jetting" produced in past designs. (Figure 2)

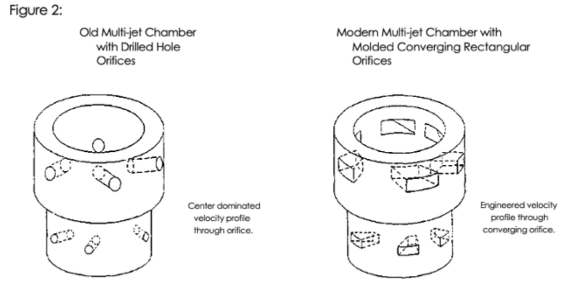
Positive displacement and multi-jet meters are designed according to different measuring principles. So what? We'd agree with PD manufacturers that each technology has its own characteristics, but the result of each is the same — accurate measurement of water. The utility manager wants an appropriately priced product to measure water accurately - the measurement principle is irrelevant.

Figure 1:



Today's multi-jet meters employ the same measuring principles as AWWA Class II Turbine Meters, also a velocity design. The measuring element of a turbine meter is a horizontal impeller; the multi-jet meter's measuring element

Figure 2:



is a vertical impeller. In both cases, water passing through the measuring chamber causes the impeller to turn. The rotation of the impeller, in both cases, is translated into registration. With both turbine and compound meters, utilities depend on the velocity principle for measuring their high revenue applications.

The next issue to address is the accuracy of multi-jet meters versus positive displacement meters. Again, let us clear up some misconceptions that linger from ancient history. Today's multi-jet meter measuring chambers are constructed of engineered thermoplastics that significantly outperform early designs' metal chambers. Today's construction materials do not encourage the significant build-up that historically occurred when metal chambers were the standard. In today's designs, in addition to material selection, the engineering attention to the pitch, shape, and size of the orifices of today's multi-jet chambers enable the dynamics of the water flow to further discourage build-up at the orifices, flushing particulates through the chambers. Also, today's engineered thermoplastics do not show the wear that was typical of the jets in metal multi-jet chambers.

Relevant to the issue of accuracy, multi-jet technology is occasionally criticized for allowing a minimal amount of water to be diverted to flow "around" a multi-jet measuring chamber (approximately 1% of the flow). Misinformed PD manufacturers cite this as a failure to measure all of the water flowing through the meter, conveniently ignoring that all PD manufacturers produce turbine meters that likewise incorporate external calibration. As stated earlier, multi-jet measurement does not depend on volume (as do PDs) but rather on velocity. With a multi-jet meter, you obtain a synchronous relationship between the velocity of the water and usage. With external calibration, a manufacturer can adjust for slight variations in the meter's machined casting surfaces (with precision injection molding equipment variations are not seen in the measuring chamber's thermoplastic components) to obtain the maximum synchronization, and thereby high accuracy. If water does not enter through the orifices and turn the impeller, there is no way that water would pass through the meter.

Multi-jet meters are inherently more accurate at low flows than positive displacement meters. In the normal operating range, both C-700 and C-708 require that meters operate within ±1-1/2%. Author Koch was involved with AWWA standards when C-708 was written, at that time as an engineer for a positive displacement manufacturer. Several PD manufacturers appealed for modifications after the first draft of C-708 was released — because it specified better performance at low flows for multi-jet meters than for positive displacement meters. As a compromise, C-700 and C-708 both allow a 6% accuracy spread at low flow. C-700 meters must operate between 95% and 101% at low flows; C-708 meters must operate between 97% and 103%. In fact, most multi-jet meters operate between 97% and 101%. Very few multi-jet meters use the full 6% accuracy spread typical of positive displacement meters, in effect providing at least 2% better accuracy at low flows than PD meters.

Meter purchasers generally expect residential meters to remain in service for twenty or more years. The issue of the longevity of meters is therefore relevant. The most critical time in a meter's life is at installation when it is often placed in an installation where the installer has failed to bleed air or flush debris from the line. The multi-jet design is inherently more survivable under these not uncommon conditions. The same precise tolerances on which a PD meter depends for accuracy are prone to damage from entrained solids and air. A multi-jet meter can pass small particles and air without damage. Certainly, no water utility intentionally introduces grit or air into their service lines. However, no utility would deny that both happen, for example, when a main line requires maintenance, and particularly for utilities that depend on wells versus groundwater. A significantly higher percentage of multi-jet meters survive these critical tests.

Next to consider is accuracy over the meter's life, raising the issue of bearing wear. Bearing wear can occur in both PD and multi-jet meters. The amount of wear is a function of the materials selected for wear points and the meter's exposure to flows at which wear can occur. In a multi-jet meter, there is friction on the lower bearing system at very low flows. (Figure 3). Above low flows, the fluid dynamics created within the measuring chamber cause the impeller to "float" in water. A recent AWWA

Research Foundation study[1] reported that 88% of typical domestic water was used at flow rates between 1 and 20 GPM. In this range, the multi-jet impeller is not in contact with the lower bearing, and "wear" cannot occur. When the meter is operating at low flows, appropriately selected materials trivialize the amount of wear that occurs.

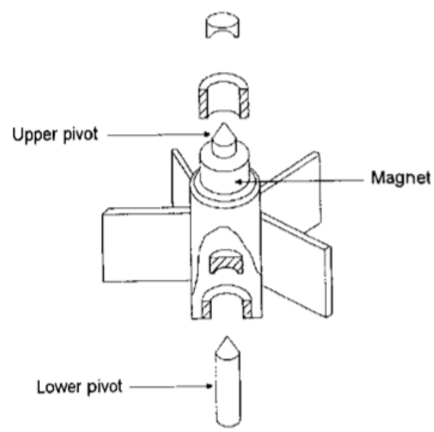
The wear points in PD meters are at the control roller, outer piston rims, division plate, and piston loop (Figure 4) or half-balls, sockets, and thrust rollers. (Figure 5) In contrast to multi-jet meters, a PD meter's wear points are active throughout the entire flow range. The entrained solids that will pass through a multi-jet meter can lodge at wear points in PD meters and abrade and erode the bearing surfaces. PD meters will run slower as their measuring surfaces wear due to additional flow slip in increasing clearances.

Much "marketing puffery" has evolved around the hypothetical bearing wear in multi-jet meters, supposedly resulting from pulsation. For some reason, a PD manufacturer has made the point that "in Europe, where multi-jets are the meter of choice, evaluation tests on-multi-jet meters are made by running 15 seconds on, 15 seconds off test for 150,000 cycles to check the effect of bearing wear." This is true. But it is also true that multi-jets pass the test and are the meter of choice throughout most of Europe!

The installation position is sometimes cited in criticism of multi-jet meters, but an equivalent criticism of installation effects on PD meters can be made. Performance comparisons in poor installations is an aberrational evaluation, not germane to the basic technology comparison. However, it should be noted that meters are installed for ease of reading, which implies horizontal installation. Further, AWWA emphasizes that the "basic requirements of an acceptable meter installation are … that it positions the meter in a horizontal plane for optimal performance."[2] The installation instructions published by several PD manufacturers also recommend horizontal installation.

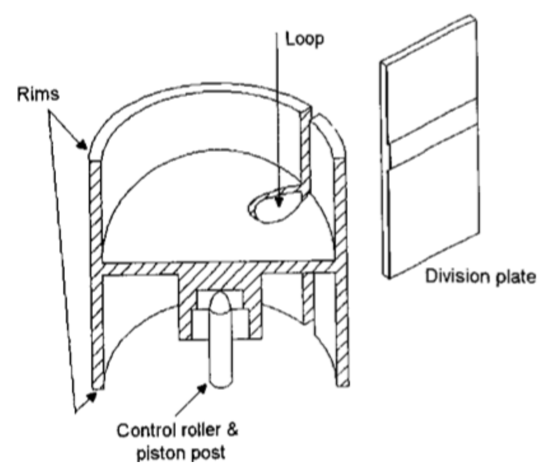
Another criticism raised against multi-jet meters is their incompatibility with generator-type remotes. An AWWA survey in 1982-84[3] reported that 87.6% of all remotes were self-powered remotes. At that point in history, the ability to drive

Figure 3:
Multi-jet Wear Surfaces at Low Flows



a self-powered remote was essential for the approximately one-third of water utilities with inside sets. While no comparable AWWA survey can be quoted for 1996, it is commonly known that encoded remotes constitute by far the most significant type of registers in current production in North America since they find application in both inside, and pit set utilities. In fact, one of the major suppliers has announced that the production of self-generator remotes will be discontinued this year. The ability of a meter to drive self-generator remotes is a non-issue in 1996. Both PD and multi-jet meters can accommodate encoded registers meeting AWWA C-707 (Encoder-Type Remote-Registration Systems). And for the few applications where it is still required, multi-jet meter manufacturers offer products meeting C-706 (Direct-Reading Remote-Registration Systems) by providing a switch

Figure 4:
Oscilating Piston Meter Wear Surfaces All Flows



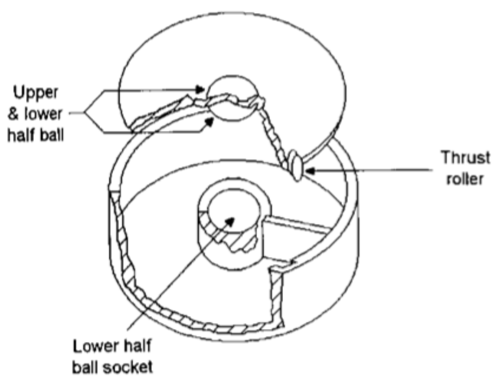
closure output to increment a remote LCD display.

In the past ten years, multi-jet manufacturers have improved designs and substituted high-tech materials for improved accuracy and longevity. Combined with the evolution of encoders as the preferred remote technology, these changes have enabled multi-jet meters to evolve as a quality measurement alternative for utilities.

The day has passed when utility managers depend on criticisms of multi-jet meters dug from PD manufacturers' archive. Knowledgeable, conscientious utility managers understand their

Figure 5:

Disc Meter Wear Surfaces All Flows



technology alternatives and select the most cost-effective product for their utility, be it positive displacement or multi-jet.

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[1] P. T. Bowen et al, "Residential Water User Patterns", AWWA Research Foundation Report, 1993.

[2] *Manual M6*, Third Edition (Denver: American Water Works Association, 1986), page 39.

[3] Donald L. Schlenger and Frank Gradilone III, "Preliminary Report - AWWA Survey of Remote Meter Reading", *AWWA Annual Conference Proceedings*, 1984, page 12.