Flow Conditioner Installation and Effects on Turbine Meters

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Introduction

Turbine meters are used extensively for the custody transfer of liquid hydrocarbons worldwide. The potential impact of inaccurate volumetric measurement due to improper turbine meter flow conditioning and installation effects could be significant. Flow conditioners and flow conditioning are designed to substantially reduce installation and operational effects. Phase II testing concentrated on operational effects. Phase I results on installation effects (for example, three elbows out of plane) were covered first in an addendum to API *MPMS* Chapter 5.3, and then included in Section 5.3.5.3.

The purpose of this Technical Report (TR) is to provide a summary of flow conditioning testing performed on turbine meters in liquid hydrocarbons. Initial testing was conducted in water, and those findings were included as an addendum to API *MPMS* Chapter 5.3 in 2009; subsequent testing in hydrocarbon liquids was carried out through July 2016.

Phase II testing focused on operational effects, specifically the relationship of strainer design, strainer basket disturbances, flow conditioning, and how they affected the flow meter deviations in hydrocarbon applications (viscosities, densities, and Reynolds number).

Phase II testing focused on four flow conditioners: one tube bundle and three high-performance flow conditioners. High-performance flow conditioners are defined as those that provide pseudo-fully developed flow in laboratory and field piping configurations. Their performance in various distorted flow profiles was measured by determining meter factor deviations. Installation and operational effects were created with piping geometry, various strainer designs, and various blockages. Obstructions were placed in the strainer basket as illustrated in the strainer blockage replication obstructions shown in Figure 2. Multiple turbine meters were used in the testing, including flat-bladed (unrimmed and rimmed) and helical types.

The testing was also not intended to establish whether a specific meter and conditioner combination worked better than a different meter and conditioner combination.

Dr. George E. Mattingly's NIST studies of flow profile in the 1980s were an instigating force in the initiation of the Ad Hoc Flow Conditioning Task Force (TF). The purpose of both Phase I (beginning about 2005 on water as a liquid) and Phase II (2010–2016) was to validate the limited documentation indicating that obstructions in strainers caused meter factor to shift of 0.25 % or more (unpredictably), and to evaluate 20D, tube bundles, and flow conditioning performance on piping disturbances and random, erratically occurring effects, such as strainer basket obstructions. This could likely reduce proving frequency. More importantly, high-performance flow conditioners would give more consistent meter reproducibility and repeatability.

These random events with flowing stream debris can't be "proved out" as effectively or rapidly as they can be "tuned out" by high-performance flow conditioning.

The conditions for the testing had process variables of flow, pressure, temperature, and viscosity that varied negligibly compared to typical field operation. The Ad Hoc Flow Conditioning TF had discussions in 2011 and 2012 regarding what might be considered acceptable variation. The TF felt meter factor variations of less than ±0.03 % were the limits of the artifact (turbine meter, flow conditioning, piping, and strainer) in the laboratory performance. The TF concurred that meter factor variations of ±0.07 % or more under the test conditions were an indication of a real shift.

In discussion by the users and the Ad Hoc Task Force, it was noted that in field conditions, variances larger than above may be considered acceptable. Acceptable meter factor variations are defined by the operations and the appropriate risk managements (such as loss/gain and line balance for leak detection).

Technical Report on Flow Conditioner Installation
and Effects on Turbine Meters

1 Scope

API *MPMS* Chapter 5.3 and parts of API *MPMS* Chapter 6 cover the installation requirements and performance characteristics of turbine meters in liquid hydrocarbon service. This research work provides data that should be considered for future incorporation into these standards.

Phase I of this flow conditioning task force was performed on water prior to 2009. As part of Phase I, an addendum was included in API *MPMS* Chapter 5, Section 5.3.5.3 and Appendix A.1, that recommended the need for flow conditioning rather than straight pipe of any length. Phase II was intended to prove or disprove whether the results on water would translate to light hydrocarbons, higher viscosities, larger line and strainer sizes, and different Reynolds numbers.

Phase II of the flow conditioning project tested several sizes and types of turbine meters, strainers, and piping arrangements with various types and arrangements of commercially available flow conditioners. This was carried out on a range of petroleum liquids to try to determine which flow conditioner arrangements provide adequate turbine meter accuracy for liquid hydrocarbon applications.

Previous work by the Ad Hoc Flow Conditioning Task Force determined that meter performance, as reflected by meter factor deviation, repeatability, and reproducibility, was sensitive to flow profile effects caused by obstructions in strainer baskets, as well as strainer basket movement.

Phase II testing continued with obstructions similar to those in Phase I (water testing), but “finger left” (D) and “finger right” (E) obstructions were eliminated part way through Phase II testing, as they were found to cause minimal change to meter factor deviation.

1.1 Configuration of Test Meter Runs (Figures 1A and 1B)

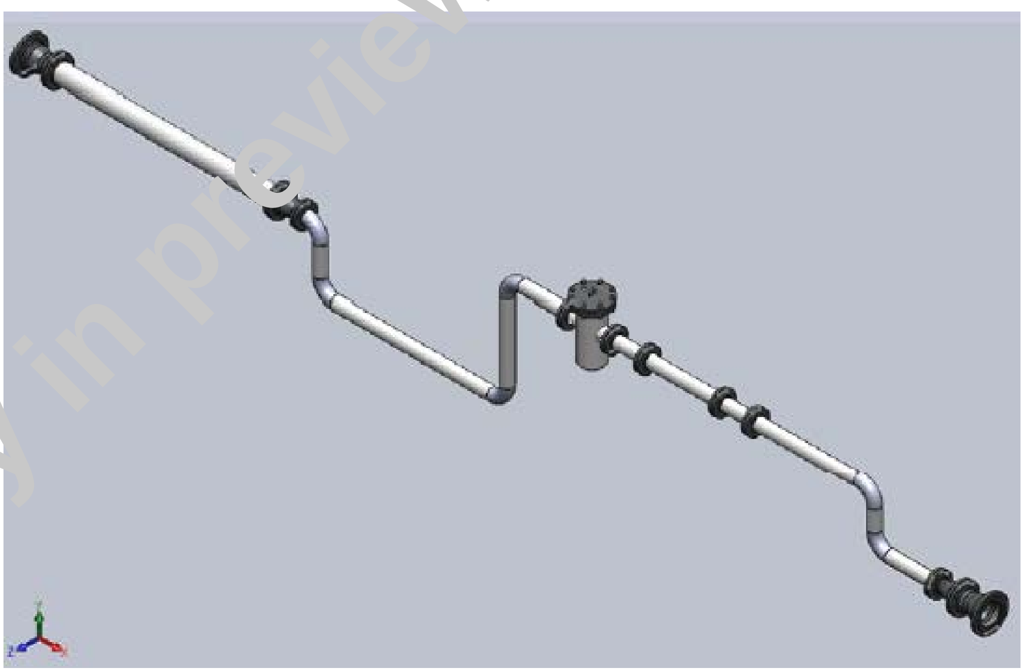

Figure 1A—Typical Test Meter Run Configuration

Figure 1B—Alternate Test Meter Run Configuration

On either configuration (above), there were five different strainer obstructions:

a) half-moon left

b) half-moon right

c) full moon

d) “finger left”

e) “finger right”

Figure 2 shows the devices utilized to replicate installation effects or varying strainer blockages. Obstructions A and B were constructed having approximately half the strainer discharge bore. Obstruction C was constructed having close to the entire strainer discharge bore. The dimensions of obstructions D and E are approximately 1” x 4” regardless of strainer discharge bore. Strainers used in testing had nozzle diameters of 4”, 6”, and 8”.