Manual of Petroleum Measurement Standards
Chapter 13—Statistical Aspects of Measuring and Sampling

Section 2—Methods of Evaluating Meter Proving Data

FIRST EDITION, NOVEMBER 1994

ERRATA 1, OCTOBER 2015

REAFFIRMED, APRIL 2019

AMERICAN PETROLEUM INSTITUTE

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ERRATA 1

Page 9, **Table 8**, row $n = 5$, 95% Confidence Level, *replace*

2.770

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Chapter 13—Statistical Aspects of Measuring and Sampling

SECTION 2—METHODS OF EVALUATING METER PROVING DATA

13.2.0 Introduction

Minimizing systematic and random errors, estimating remaining errors, and informing affected parties of errors are becoming increasingly important to the petroleum industry. A consistent basis of estimating the size and significance of errors is essential for communications between affected parties. A consistent basis of estimating and controlling errors can help to avoid disputes and dispel delusions on the accuracy of activities and equipment related to meter proving operations.

A wide range of designs, equipment, and service operating conditions is experienced in meter proving operations. Because of these variations, it is impractical to establish fixed procedures for maintenance, calibration, and proving activities for all installations.

Meter proving factors (meter factors) are normally monitored to detect trends or sudden deviations as indications of when to perform maintenance and calibration of measurement equipment.

The purpose of this chapter is to provide procedures for recording, analyzing, and controlling variations in meter factors so that random uncertainties are understood and consistent with the objectives of parties affected by the measurement operations. Limits on meter factor variations are left to the agreement of parties affected by the measurement operations.

13.2.1 Scope

Chapter 13.2 will address procedures for evaluating any meter's performance where meter proving factors are developed in accordance with Chapter 12.2. The data in examples used in this chapter are intended to be typical of custody transfer operations of low-vapor-pressure fluids using displacement or turbine meters in accordance with Chapters 4, 5, and 6 of the *Manual of Petroleum Measurement Standards*. However, the procedures in Chapter 13.2 can be used for non-custody transfer metering applications and for custody transfer metering of high-vapor-pressure and gaseous fluids where meter proving data are available.

Procedures and examples are given for analyzing the random uncertainties associated with meter proving data (see note). Procedures and examples are also given for evaluating and controlling trends in meter factors with control charts and control logs to ensure that meter factor variations exhibit a random nature that results in the propagation of a lower average uncertainty in measurements with time and throughput.

Note: Uncertainty computations are based on procedures given in Chapter 13.1 of the *Manual of Petroleum Measurement Standards*.

Since no single document can cover all of the statistical procedures and applications being practiced, procedures other than those appearing herein may be used. Alternate statistical procedures are not expected to duplicate the computational values provided by procedures in this chapter. However, alternative procedures should achieve the same purpose intended by the procedures given herein. When alternative statistical computational procedures are to be used and affect metered quantities, parties directly involved with the metering operations should be notified prior to their implementation.

Some of the procedures in Chapter 13.2 are suitable for hand calculations and graphs employed by field personnel. These procedures are discussed and illustrated in 13.2.5 of this chapter. However, the statistical evaluations and control charts are generally too rigorous for manual field computations, and computers should be employed. The statistical procedures in this document may serve as a guide for developing software for computer applications.

13.2.2 Definitions

The following definitions supplement the definitions appearing in Chapter 13.1.

Action limits are control limits applied to a control chart or log to indicate when action is necessary to inspect or calibrate equipment and possibly issue a correction ticket. Action limits are normally based on 95 percent to 99 percent confidence levels for statistical uncertainty analyses of the group of measurements.

Control chart is a graphical method for evaluating whether meter proving operations are in or out of a state of statistical control.

Control log is a tabular method for evaluating whether meter proving operations are in or out of a state of statistical control.

Control chart or *log, fixed limit* is a control chart or log whose control limits are based on adopted fixed values applicable to the statistical measurements displayed on the log or chart. Historically, fixed limits have been used to control the limits on meter factor changes.

Control chart or *log, no fixed limit* is a control chart or log whose control limits are based on the statistical variations of measurements displayed on the chart or log.

Control limits are limits applied to a control chart or log to indicate the need for action and/or whether or not data is in a state of statistical control. Several control limits can be applied to a single control chart or log to determine when various levels of action are warranted. Terms used to describe