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NOVA METCON
INTERCHANGEABILITY OF TURBINE MODULES

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1.0 EXECUTIVE SUMMARY

The objective of this work was to determine the effect on meter accuracy of swapping out turbine meter modules. The first phase of the work involved doing a survey of literature to determine if such information already exists and whether additional testing is needed to quantify potential accuracy issues with turbine meter module swaps.

Based on the documentation available from previous testing concerned with the effect on meter accuracy of swapping out meter modules (or cartridges) between different bodies, it appears that meter accuracy is expected to be within at least $\pm$ 0.35% for primary rotor calculated flows and even better than $\pm$ 0.17% when using the auto-adjust feature of the Sensus AAT-II. With this information available it was concluded that no further work is needed in this area to meet the current needs of METCON members.

2.0 INTRODUCTION

This document presents the results of an investigation performed under the auspices of the NOVA Metering Consortium (METCON). The Consortium was formed to test and evaluate the performance of new metering and instrumentation technologies, providing industry with the necessary information to make informed decisions concerning the suitability of new technologies to various applications. Information remains confidential to METCON members for two years, after which time it may be released for publication.

It is the practice by pipeline companies that use turbine meters with removable measurement modules to send only the measurement module for calibration. To reduce down time the module being removed may be replaced by another recently calibrated module of the same specification. Error shifts on the order of 0.2% have been reported due to this practice. There is interest to evaluate this error shift in meter performance in a custody transfer meter run configuration when subjected to baseline flow conditions.

Phase 1 of the project involved first determining what documentation about this subject is already available. Based on these findings it would then be decided whether a Phase 2 would be required to do testing.

3.0 METHOD

To determine what documentation was already available on this subject, a literature review was done to determine to what extent, if any, previous testing has been done concerning this topic. A recommendation to perform a test phase component of this project or not was to be reached based on whether previous testing had been done and, if so, the availability and quality of results available for review.

4.0 RESULTS

Available documents concerning previous tests to evaluate the effect on turbine meter performance of changing out meter modules or cartridges with different bodies have been reviewed.

The three documents that have been reviewed are summarized here.

4.1 GRI REPORT # GRI-04/0207, "EFFECTS OF TURBINE METER CARTRIDGE CHANGE-OUT ON MEASUREMENT UNCERTAINTY" [1]

The GRI Report [1] was published in 2005. The work was done at Southwest Research Institute (SWRI). All meters tested were 4-inch size and were manufactured by American Accu Test, Daniel, and Sensus (Mark II and AAT-II). The Daniel and Sensus Mark II meters were single rotor meters. The American Accu Test and Sensus AAT-II were dual rotor meters, although only the Sensus AAT-II had fluid-coupled rotors so that an adjusted flow rate could be calculated. The second rotor of the American Accu Test meter was independent of the primary rotor and was used only for an independent calculation of K factor, hence flow rate. New and used meters were tested, and both standard (Q_{max} = 18,000 ACFH) and high capacity (Q_{max} >18,000) versions were tested for each model. Testing was done in natural gas at line pressures of 190 psi in flows at 20, 50, and 80% of Q_{max} for each meter.

Spreads in primary K factor, from lowest to highest relative to the mid-range value, were reported for the cartridge performance in different meter bodies. Similarly, the spread in adjusted flow rate was also reported for the Sensus AAT-II. Percent spreads in primary rotor K factors ranged from $\pm$0.01% to $\pm$0.35%. The spread in Sensus AAT-II adjusted flow rates were as high as $\pm$0.17%. It was found that meter bodies with the smallest dimensional variations minimized the changes in cartridge performance.

4.2 DANIEL FLOW PRODUCTS REPORT # 94-FD-03, "INTERCHANGEABILITY OF DANIEL GAS TURBINE METER INTERNALS AND METER BODIES" [2]

The Daniel report [2] was provided by Dan Hackett. It is also available from the CEESI document library. The report describes the results of testing done on 4-inch Daniel meters in 1994. The meters were single rotor meters and five 4-inch cartridges were calibrated in 4 different meter bodies. Testing was done at the Colorado Engineering Experiment Station, Inc. (CEESI), Nunn, Colorado, in high pressure air. Line pressure for the tests was 450 psig, which allowed for an air density similar to that of natural gas at 750 psig. Meters were evaluated in flows of approximately 20, 40, 60, and 80% of the meter Q_{max}. The reasoning for testing 4-inch meters was that since the design also applied to larger meters of 6, 8, and 12 inches and manufacturing tolerances of the larger meters were similar to those of the 4 inch meter, the 4-inch meter was expected to have the worst tolerances when expressed as a ratio of the meter diameter. It can thus be implied that variations in K factor would be expected to be less for the larger meters. From the results of the testing, it was concluded that the measurement uncertainty of any meter output was expected to be better than $\pm$0.3%, even when changing the cartridge from one meter body to the other.

4.3 A SUMMARY OF SENSUS "TURBINE METER BODY INTERCHANGEABILITY TESTING"

This summary (consisting primarily of output data tables) was provided by Wayne Wenger of Kinder Morgan. Testing by Sensus (then Invensys Metering Systems), at their test facilities, for different meters in different time periods under different conditions are reported.

The most recent test period, and probably the only one relevant for METCON's interests, was February 1993 when 4, 6, 8, and 12 inch AAT-II meters were tested in air at pressures of atmospheric, 50 and 850 psig for flow rates of 20 and 80% of Q_{max}. The variation on meter K-factor from changing cartridges from one body to the other was reported as generally about $\pm$ 0.12% for both the mechanical K-factor and auto-adjusted calculated flow rates.

Test results at atmospheric pressure were also reported for a 4-inch AAT-I in February 1987. Flow rates were set at 10, 50, and 100% of Q_{max}. Mechanical- and adjusted-based flow rates had ranges between meter bodies of $\pm$0.21 and $\pm$0.20 percent, respectively.

A third set of test results is reported from a period ranging from 1971 to 1973. These were taken with single rotor, 4, 6, 8, and 12 inch Mark II meters at atmospheric and elevated pressures (no value given) for 3 different flow rates (no values given). Variation in calibrated K-factors ranged from ± 0.26 to ± 0.39%.

5.0 SUMMARY OF REVIEW

Based on the documentation available from previous testing concerned with the effect on meter accuracy of swapping out meter modules (or cartridges) between different bodies, it appears that meter accuracy is expected to be within at least ± 0.35% for primary rotor calculated flows and even better than ± 0.17% when using the auto-adjust feature of the Sensus AAT-II.

In addition to performing this review, before the review was completed a request was made to Dan Hackett, Emerson Group, to participate in this project as a METCON manufacturer member and supply two Daniel turbine meters (Daniel 2015 ANSI#600 8-inch turbine meters) for testing. The reply was that Daniel would not be interested in participating in this project as they consider flow measurement using turbine meters to be a mature technology. Dan cited the study results published by GRI and Daniel (see section 4) as providing sufficient information about the effect on metering performance of changing cartridges from one meter body to the other.

Upon communicating the results of this Phase 1 investigation, METCON members agreed that there was no need to pursue this work with a Phase 2 for testing of meter modules since it appears the necessary data is already available. This project was thus terminated upon completion of this Phase 1 literature review.

6.0 REFERENCES

[1] Sibenaler, S.P. and George, D.L., (2005) *Effects of turbine meter cartridge change-out on measurement uncertainty*, Metering Research Facility Program Topical Report, Southwest Research Institute, prepared for Gas Research Institute, GRI-04/0207, March 2005.

[2] Goodson, D. and Husain, Z., (1994) *Interchangeability of Daniel gas turbine meter internals and meter bodies,* Daniel Flow Products, Inc., Report No. 94-FD-03, October 1994.

7.0 ACKNOWLEDGEMENTS

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