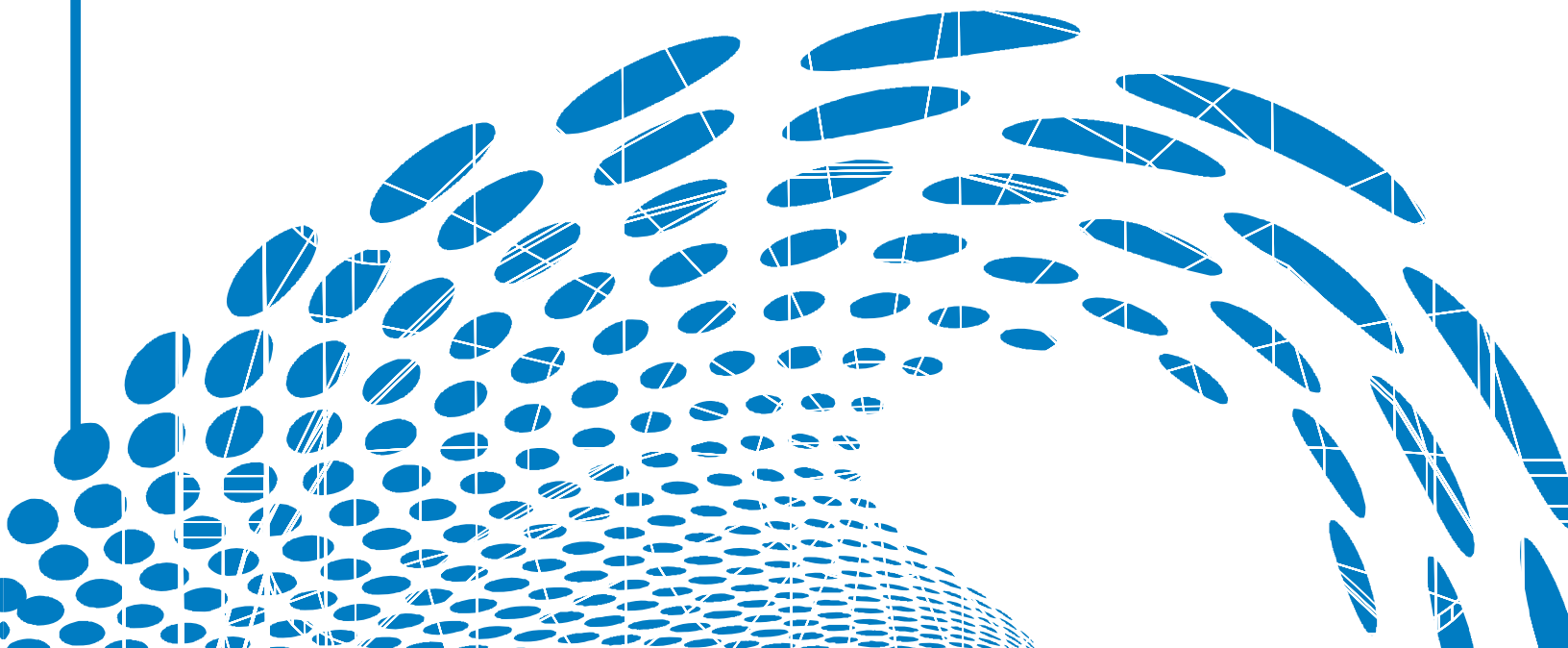
ASME STANDARDS TECHNOLOGY, LLC

STP-TS-084

Orifice Flow Coefficient Equation Comparison



STP-TS-084

ORIFICE FLOW COEFFICIENT EQUATION COMPARISON

Prepared by:

Casey Hodges
CEESI Measurement Solutions, Inc.

Date of Issuance: June 27, 2018

This publication was prepared by ASME Standards Technology, LLC (“ASME ST-LLC”) and sponsored by The American Society of Mechanical Engineers (“ASME”).

ASME Standards Technology, LLC
Two Park Avenue, New York, NY 10016-5990

ISBN No. 978-0-7918-7178-2

TABLE OF CONTENTS

LIST OF TABLES AND FIGURES

FOREWORD

This report analyzes four flange tap equations and three corner tap equations for the discharge coefficient for orifice plates. All of the equations analyzed are functions of Beta Ratios, Reynolds Number, and Line Size, and all data points were evaluated against each of the seven orifice flow coefficient equations described in more detail herein. The goals of the study were to review the data available to determine where any weak regions of the database may be, to provide a methodology for comparing the equations over a range of Reynolds Numbers, Line Sizes, and Beta Ratios, and to determine the performance of each equation in relationship to the appropriate available database of calibration data.

Established in 1880, the ASME is a professional not-for-profit organization with more than 135,000 members and volunteers promoting the art, science and practice of mechanical and multidisciplinary engineering and allied sciences. ASME develops codes and standards that enhance public safety, and provides lifelong learning and technical exchange opportunities benefiting the engineering and technology community. Visit https://www.asme.org/ for more information.

ASME ST-LLC is a not-for-profit Limited Liability Company, with ASME as the sole member, formed in 2004 to carry out work related to new and developing technology. ASME ST-LLC's mission includes meeting the needs of industry and government by providing new standards-related products and services, which advance the application of emerging and newly commercialized science and technology, and providing the research and technology development needed to establish and maintain the technical relevance of codes and standards. Visit http://asmestllc.org/ for more information.

EXECUTIVE SUMMARY

CEESI Measurement Solutions, Inc. (CMSI) was contracted by ASME ST-LLC to perform analysis of the performance of the equations for the discharge coefficient for orifice plates. Each equation was compared to the appropriate available database of calibration data. The goals of the study were to:

(a) Review the data available to determine where any weak regions of the database may be;

(b) Provide a methodology for comparing the equations over a range of Reynolds Numbers, Line Sizes, and Beta Ratios; and

(c) Determine the performance of each equation in relationship to the database data.

Flange Tap Equations

CMSI performed a rigorous evaluation of the dataset in comparison to the equations, and found the following main conclusions in regard to the Flange Tap Equations:

(a) Following the analysis methodology described in Section 3 herein, the average deviation of the database data from each equation was:

(1) ASME MFC-3M 2004 (ISO-RHG): +0.06 percent

(2) ISO 5167 1991 (Stoltz): -0.13 percent

(3) AGA Report Number 3 1990 (AGA-RHG): 0.00 percent

(4) PTC 19.5 Appendix 1 (Keyser): -0.12 percent

(b) The number of regions with Average Deviations further than two standard deviations from Equation Values were determined to be:

(1) ASME MFC-3M 2004 (ISO-RHG): one of forty-one regions outside

(2) ISO 5167 1991 (Stoltz): two of thirty-nine regions outside

(3) AGA Report Number 3 1990 (AGA-RHG): zero of forty-one regions outside

(4) PTC 19.5 Appendix 1 (Keyser): three of thirty-six regions outside

(c) Over most of the range of the equation, the ASME MFC-3M 2004 (ISO-RHG), ISO 5167 1991 (Stoltz), and AGA Report Number 3 1990 (AGA-RHG) equations are within the uncertainties of the equations. The exception to this is in the 2-inch Line Size.

(d) In the 2-inch Line Size, where there is the largest difference between equations, the ASME MFC-3M 2004 (ISO-RHG) equation fits the database better than the other equations.

(e) It is not clear which of the data from this database were used in the regression, but it is clear that three of the equations show very good agreement with the database.

(f) The PTC 19.5 Appendix 1 (Keyser) Equation deviates from the other equations and the calibration data at low Reynolds Numbers; therefore, the PTC 19.5 Appendix 1 (Keyser) Equation should not be used for extrapolation with calibration data at low Reynolds Numbers. Due to the slope of the PTC 19.5 Appendix 1 (Keyser) Equation, it is not the best equation to use for extrapolation. The point at which the PTC 19.5 Appendix 1 (Keyser) Equation could be used is as a function of Line Size and Beta Ratio, and this should be taken into consideration before performing any extrapolation with the PTC 19.5 Appendix 1 (Keyser) Equation.

Therefore, when utilizing a flange tap orifice plate, CMSI recommends utilizing the ASME MFC-3M 2004 (ISO-RHG) Equation, as it fits the entire database well, and specifically covers the 2-inch Line Size very well. The AGA Report Number 3 1990 (AGA-RHG) equation is statistically equal to the ASME MFC-3M 2004 (ISO-RHG) over almost all of the regions of applicability of the two equations.