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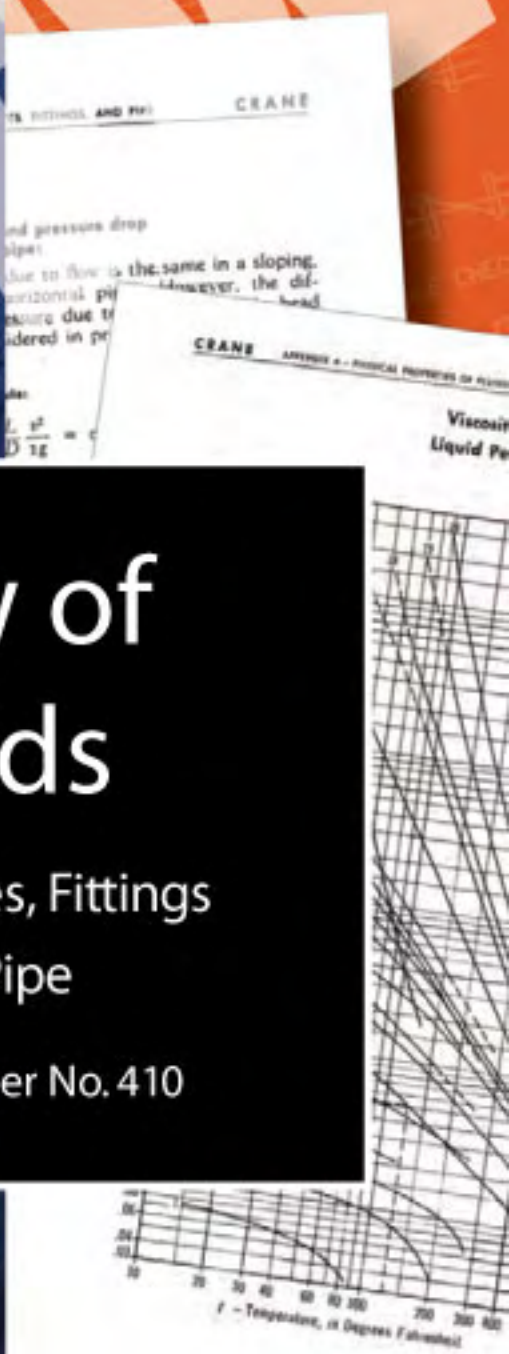

Flow of Fluids

Through Valves, Fittings and Pipe

Technical Paper No. 410

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By the Engineering Department

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Foreword

In the 21st century, the global industrial base continues to expand. Fluid handling is still at the heart of new, more complex processes and applications. In the 19th century, water was the only important fluid which was conveyed from one point to another in pipe. Today, almost every conceivable fluid is handled in pipe during its production, processing, transportation, or utilization. In the 1950's new fluids such as liquid metals i.e., sodium, potassium, and bismuth, as well as liquid oxygen, nitrogen, etc., were added to the list of more common fluids such as oil, water, gases, acids, and liquors that were being transported in pipe at the time. In the current decade of new technologies, heat-transfer fluids for solar plants, mineral slurries, and new chemical compounds expand the envelope of materials of construction, design, process pressures and temperature extremes as never before. Transporting fluids is not the only phase of hydraulics which warrants attention either. Hydraulic and pneumatic mechanisms are used extensively for the precise controls of modern aircraft, sea-going vessels, automotive equipment, machine tools, earth-moving and road-building machines, scientific laboratory equipment, and massive refineries where precise control of fluid flow is required for plant automation.

So extensive are the applications of hydraulic and fluid mechanics that most engineering disciplines have found it necessary to teach at least the elementary laws of fluid flow. To satisfy a demand for a simple and practical treatment of the subject of flow in pipe, Crane Co. in 1935, first published a booklet entitled Flow of Fluids and Heat Transmission. A revised edition on the subject of Flow of Fluids Through Valves, Fittings, and Pipe was published in 1942 as Technical Paper 409. In 1957, a completely new edition with an all-new format was introduced as Technical Paper No. 410. In T.P. 410, Crane endeavored to present the latest available information on flow of fluids, in summarized form with all auxiliary data necessary to the solution of all but the most unusual fluid flow problems.

The 1976 edition presented a conceptual change regarding the values of Equivalent Length L/D and Resistance Coefficient K for valves and fittings relative to the friction factor in pipes. This change had a relatively minor effect on most problems dealing with flow conditions that result in Reynolds numbers falling in the turbulent zone. However, for flow in the laminar zone, the change avoided a significant overstatement of pressure drop. Consistent with this conceptual revision, the resistance to flow through valves and fittings became expressed in terms of resistance coefficient K instead of equivalent length L/D, and the coverage of valve and fitting types was expanded. Further important revisions included updating of steam viscosity data, orifice coefficients, and nozzle coefficients. As in previous printings, nomographs were included for the use of those engineers who preferred graphical methods of solving some of the more simple problems.

In the 2009 edition of Technical Paper 410, Crane Co. has now included new flow control and measurement components to the pages of this paper. Pumps and Control Valves, critical elements of fluid handling, are included for the first time, as well as Flow Meters, and several additional types of valves and fittings. We have added new illustrations and updated the content throughout. Many of the nomographs have been replaced with online calculators. Visit www.flowoffluids.com for the latest data.

Originally, data on flow through valves and fittings were obtained by carefully conducted experiments in the Crane Engineering Laboratories. For this 2009 update, additional tests were performed within Crane to increase the number of valves with defined resistance coefficients. In addition, industry research was also gathered and refined to provide the reader with the latest methods for calculating hydraulic resistance. Resistance values for fittings were correlated with existing industry research and, when appropriate, more updated methods are provided in this paper, particularly seen with the new treatment of Tees and the addition of Wyes.

Since the last major update of TP-410, personal computers and Web applications have become the computational tools of choice. To meet the needs of today's engineers we have presented a variety of proven computational methods to simplify fluid flow calculations for those interested in developing custom spreadsheets or computer programs. In addition, Flow of Fluids has its own web site (www.flowoffluids.com) with a variety of Web based tools to simplify your most common fluid flow calculations.

The 2009 version of the Technical Paper 410 employs the most current references and specifications dealing with flow through valves, fittings, pipes, pumps, control valves and flow meters. The fluid property data found in Appendix A has been updated to reflect the current research on estimating fluid property data with references for the data cited throughout the paper.

From 1957 until the present, there have been numerous printings of Technical Paper No. 410. Each successive printing is updated, as necessary, to reflect the latest flow information available. This continual updating, we believe, serves the best interests of the users of this publication. The Flow of Fluids software and updated web site provide users with electronic tools and a source for the latest information. We welcome your input for improvement.

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Table of Contents

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