Purpose and Background

Water hammer may endanger pipeline equipment and may compromise personal safety. What causes water hammer? How can these conditions be anticipated, predicted and modeled? Is it possible to reduce the severity of these conditions through proper design or control?

This course emphasizes the development of an understanding of unsteady liquid pipeline flows with a particular emphasis on wave propagation phenomena. Care is given to concepts that distinguish normal unsteady flow events from more rapid undesirable events. Numerical modeling techniques are developed and demonstrated by solving practical problems encountered in water supply, sewerage and storm water transmission, power, and oil industries.

With their extensive experience in research, consulting, software development, and teaching, the instructors offer a practical, understandable course that should enable participants to recognize, analyze, simulate, and solve problems related to unsteady flows in pipeline systems. Lectures, real-life examples, demonstrations, and problem solving, including hands-on computer simulations, comprise the format of the course.

Seminar Instructors

E. Benjamin Wylie, Ph.D., P.E., F. ASCE, is Professor Emeritus of Civil and Environmental Engineering at the University of Michigan, Ann Arbor, Michigan. From 1965 to 1999, he and Professor Victor L. Streeter developed and maintained a strong research and educational program in fluid transients that has shaped the current engineering practice on transients in pipeline systems. Various editions of their textbooks on fluid mechanics and fluid transients have been the standard references for engineers and researchers in the U.S. and overseas. Dr. Wylie has been an award-winning educator and a much sought-after consultant to industry and government.

Jim C.P. Liou, Ph.D., P.E., M.ASCE, is a Professor of Civil Engineering at the University of Idaho, Moscow, Idaho, and a guest lecturer at the IHE-Delft, The Netherlands. He is engaged in research on fluid transients and real-time pipeline leak detection. Prior to his present position, he was with Bechtel Inc. in Ann Arbor, Michigan for three years and then with Stoner Associates, Inc. in Carlisle, Pennsylvania for seven years. He has experience in design, field investigation, and software development related to fluid transients. He stays involved with engineering practice by being a consultant to the water, power, and oil pipeline industries.

For group training, contact John Wyrick (JWyrick@asce.org) or Stephanie Tomlinson (STomlinson@asce.org)
Summary Outline

**Day One**

**Introduction**
- Occurrence of transients and engineering relevance
- Definitions
- Physical principles
- Wave speed and potential surge

**Method of Characteristics**
- Method formulation
- Wave propagation
- Numerical solution procedure
- Equipment modeling
- Schematization issues

**Single Pipe Example**
- General features of computer codes
- Results interpretation
- Attenuation and line pack
- Viewing transients in time-distance plane
- Examples by animations

**Wave Transmission and Reflection**
- Diameter and/or wave speed change
- In-line orifices and valves
- Trapped gas mass and air chambers
- Surge tanks and stand pipes

**Day Two**

**Valves**
- Inherent control valve characteristics
- System response to valving
- Effective control valve closure time
- Air valve modeling and sizing
- Surge relief valves

**Pumps**
- Homologous relationships
- Four-quadrant head and torque characterization
- Effect of pump speed change on transients
- Example of pump power failure transients

**Liquid Column Separation**
- The phenomenon and demonstration
- Relevance to pipeline design
- The presence of free gas and the discrete free-gas cavity model
- Effect of pipe slope and frictional gradient
- Comparisons between simulations and test data

**Control of Transients**
- System time constants and control strategy
- Experience with surge control design
- Discussions of real-life examples with various surge control schemes

**Summary**

**Seminar Benefits**
- Recognize and avoid potential danger and costly blunders in designing systems
- Understand water hammer phenomena in pipelines
- Evaluate whether a system needs water hammer analysis
- Understand and effectively use existing software for analysis and design
- Learn to recognize and identify cause(s) of harmful transients
- Gain insights on transients through discussions with instructors and participants
- Use simplified calculations to assess the likely severity of potential events
- Develop physical and numerical concepts in simulating transients in practical systems

**Who Should Attend?**
- Those needing to grasp the basic concepts of water hammer and an overview of engineering practice in this specialty
- Both newcomers and seasoned professionals in the design, operation, and maintenance of water systems
- Consultants and personnel from government agencies and academia who are involved with pipeline infrastructure

**CEUs/PDHs**
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