THE SZEWALSKI INSTITUTE OF FLUID-FLOW MACHINERY, PAS (IMP PAN)
CENTRE FOR MECHANICS OF LIQUIDS
DEPARTMENT OF HYDRAULIC MACHINERY

NUMERICAL SIMULATION OF TRANSIENT FLOW IN PIPELINES INCLUDING UNSTEADY FRICTION MODELLING

The special computer program for simulation of the unsteady flow in pipelines has been developed in the Szewalski Institute of Fluid-Flow Machinery (IFFM). The program is based on the method of characteristics used for solving the equations describing the unsteady flow in the one-dimensional space. This method, because of its simplicity and dedication to physics of such flows, is very commonly used in engineering practice. One of the most important advantages of this method is an ability to implement various models of friction losses in relatively simple way. The friction models of Zielke (1968), Trikha (1975), Vardy & Brown (2003), Zarzycki (2004), Bruno et al. (1991) have been considered in the developed program.

Calculations obtained using this computer program have been verified basing on many experimental test results executed in a wide range of Reynolds numbers (up to Re =~ 30 000) in laboratory test rig constructed in the Institute (RPV system – see figure). Thanks to a special drive of the shut-down valve which enabled a very quick closing of this valve (even in 0.003 s) an almost stepwise flow cut-off was induced in the pipeline. Such solution helped to minimize the influence of flow characteristics of the valve exerted on the shape and the course of the pressure wave induced in the pipeline in the form of water hammer phenomenon.

The pressure measured at four equidistantly spaced pipeline cross-sections and the suitable calculated pressure allowed to conduct qualitative and quantitative analysis of conformity. The main goal was to assess the usefulness of the available unsteady friction models for simulating transient flows in pipelines. The quantitative analysis used an original methodology based on the Rate of Pressure Traces Convergences as well as on the Logarithmic Decrement of Pressure Wave Damping.

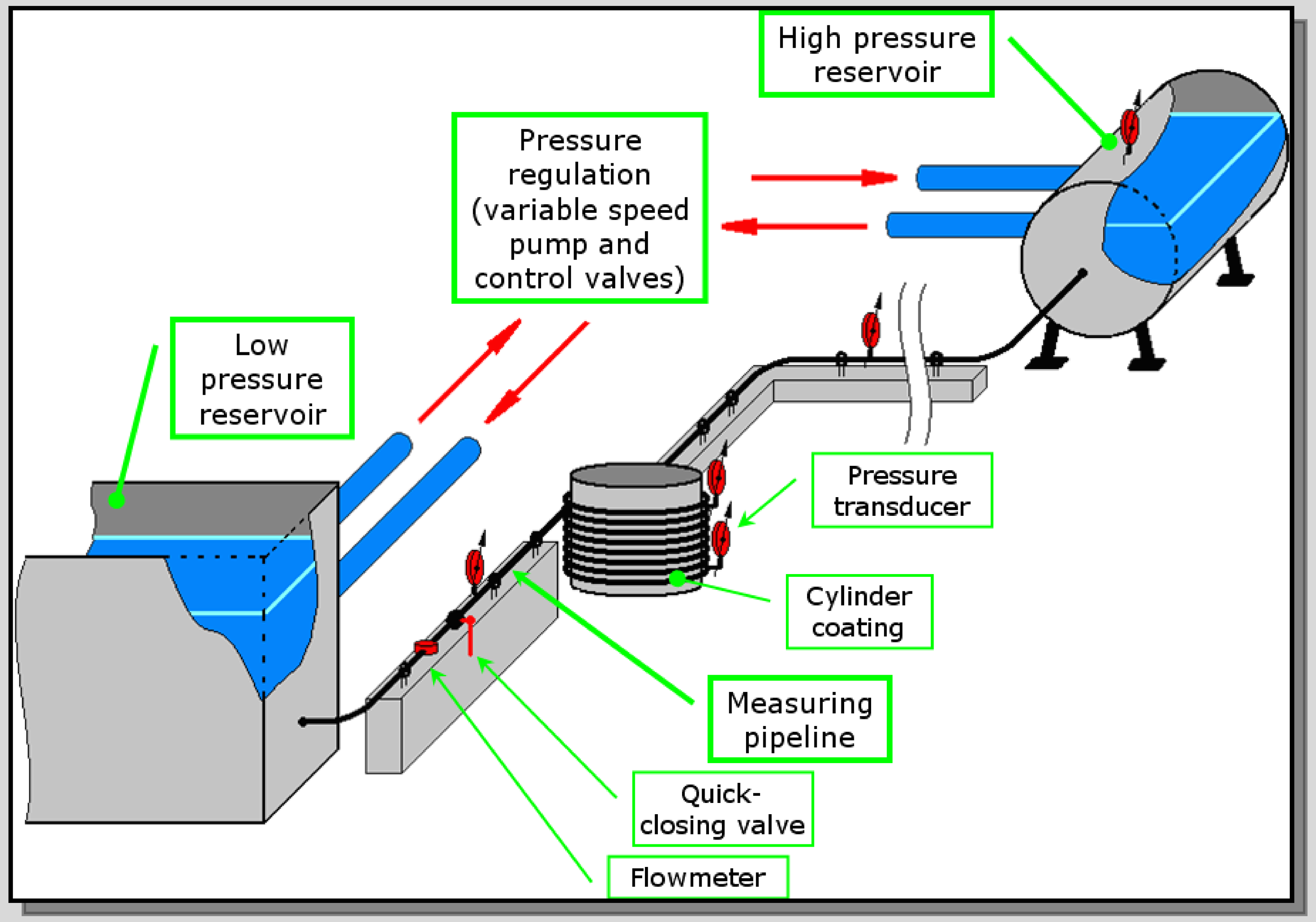

Fig. 1. Layout of the laboratory test rig used for investigation of the water hammer in pipelines (reservoir-pipeline-shut-off valve [RPV] system)

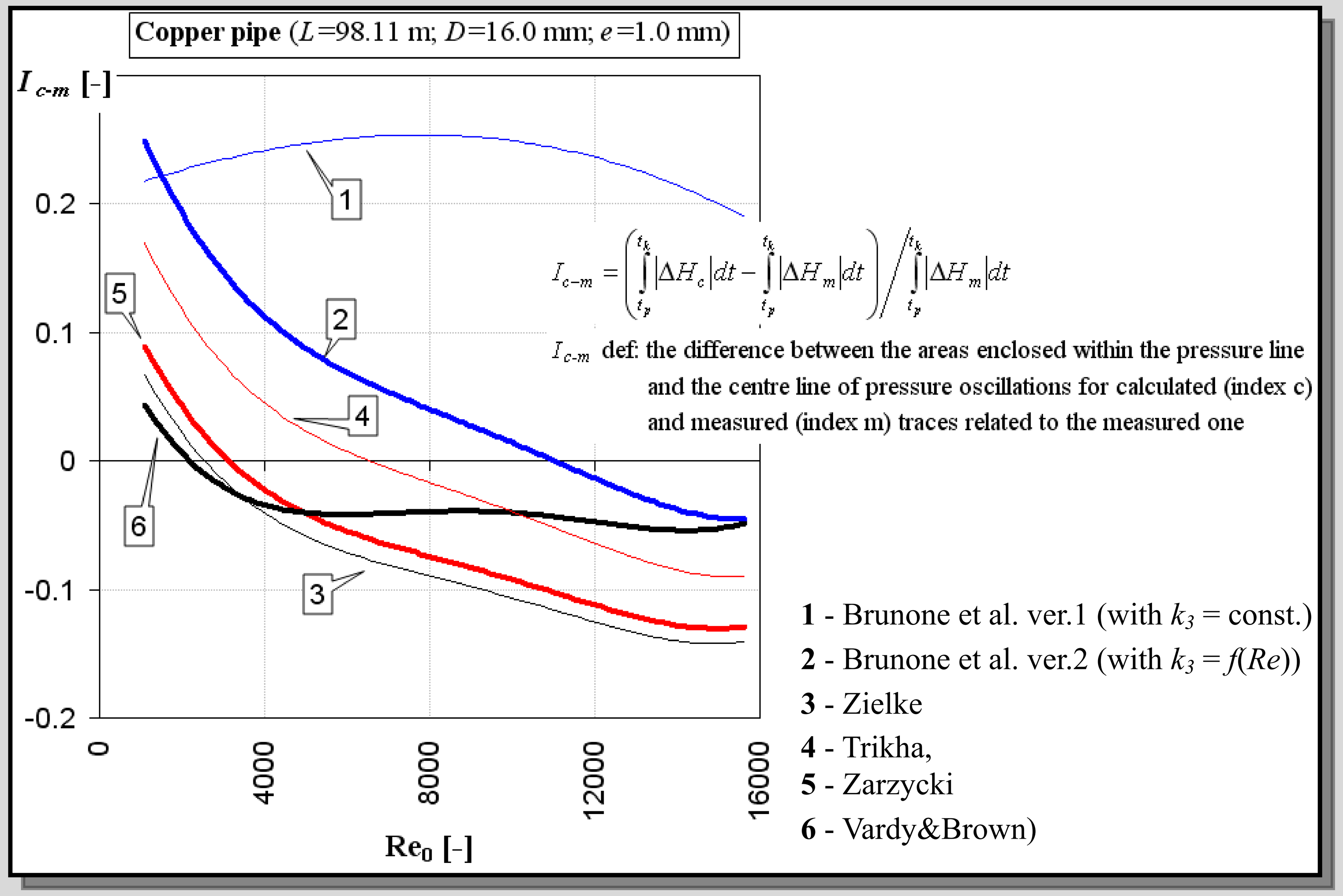

Fig. 2. Example of a comparative analysis based on the rate of pressure traces convergences I_{c-m} - changes of this quantity are presented as a function of Re_0 changes (Reynolds number in initial conditions of the tests) for the selected unsteady friction models.

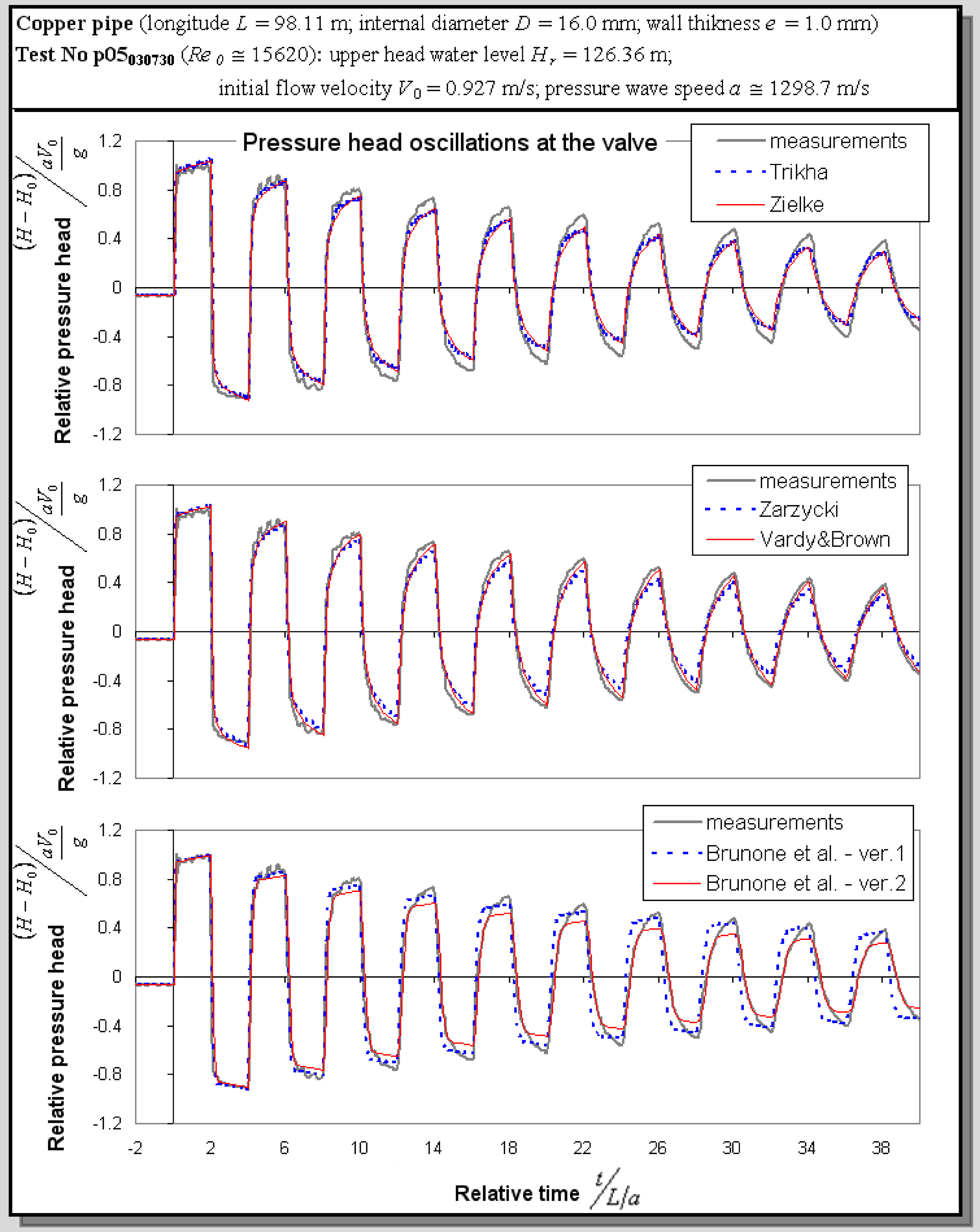

Fig. 3. Example of qualitative comparative analysis of the measurement and calculation results of in pressure head oscillations at the shut-off valve used to assess the selected unsteady friction models.

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