16. Tele-Calibrations and Advanced Ultrasonic Flow Metering.

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Objectives: (1) Demonstrate the feasibility of using information technology (IT) to expand NIST's calibration services via tele-presence in U.S. secondary calibration laboratories and to enable remote calibration, traceability, and accreditation of other U.S. metrology laboratories. (2) Assess the potential of ultrasonic technology for improving flow measurements and to develop the next generation of primary flow measurement standards.

Problem: Although the NIST fluid flow capabilities provides calibration services over five decades in flow, U.S. industry has critical needs for gas measurement traceability at much larger flow rates (ranging to 1.0×10^8 slm), a wide range of working pressures (1 – 60 atm), and many gas species. The construction of facilities capable of handling such large flow rates at NIST is impractical due to capital and space constraints. However, a small number of U.S. secondary metrology laboratories are capable of calibrating gas flow meters at much higher flows than those attainable by NIST, although with no direct flow traceability to a national standard.

Approach: For the last two years, CSTL has conducted research to develop technology needed to deliver NIST flow calibrations at remote testing sites. The approach is based in two concepts: tele-calibration and advanced ultrasonic flow metering. Tele-calibration is an IT usage that enables remote monitoring of testing facilities. We are developing method to achieve *metrological control* of remote testing facilities based on: flow assessment units, Ethernet-based distributed control, multi-user Internet collaboration tools, and digital flow rate control. Last year, CSTL successfully demonstrated the concept by calibrating a flow meter in our low gas flow facility from a remote location within the NIST Gaithersburg Campus. This year efforts focused on the transfer of the technology to a secondary metrology laboratory, Colorado Engineering Experimental Station, Inc. (CEESI), that has high flow rate calibration facilities.

Achievement of metrological control through the use of advanced sensors will enable NIST metrologists to gain insight into the flow conditions prevalent at the time of testing. In this project such a *flow assessment unit* takes the form of an 11-path ultrasonic flow meter capable of classifying flow field disturbances present in the testing pipeline, e.g., disturbance produced by a half-open valve upstream of the meter-under-test. The flow field classification is accomplished via the match of non-contact ultrasonic sensing technology and pattern recognition software.

Results and Future Plans: Daniel (a flow meter manufacturing division of Emerson Electric Company and a member of the Fisher-Rosemount group) provided us with a 4-path working model of their 200-mm Senior Sonic™ ultrasonic flow meter. We stripped the software provided and replaced it with pattern-recognition software based on learning automata (i.e., artificial intelligence). The flow field recognizer was "taught" the relationship between an input vector (i.e., the 4 sensed velocities) and a flow classification (e.g., ideal pipe flow, flow downstream from an elbow, flow downstream from an orifice plate, etc.). After training, the sensor was capable of differentiating among nine different disturbances. Based on these results, we felt ready to request the construction of the 11-path meter, which should be tested in the coming year.

Early in the year, we visited the CEESI's Nunn facilities to assess instrumentation needs of their *Primary A* flow calibration facility, a volumetric calibrator of the blow-down PVTt type, that presents some unique challenges due to siting of its components. This presents problems in routing instrumentation and in monitoring all activities and access to the high-pressure vessel due to very limited access for essential temperature instrumentation, a critical parameter in proper operation of PVTt systems. Both pressure control and the system's custom-made diverter valves are manual and in need of tele-operation capability.

To overcome these difficulties a reduced scale version of the CEESI facility will be replicated at NIST so that we can study the transient characteristics of the instrumentation and control systems. Pressure and temperature instrumentation of the required accuracy will be obtained, recognizing the particular needs of the blow-down dynamics of this PVTt system. Currently we anticipate commencing the installation of equipment at the CEESI facility by the end of the 2001 summer.

Publications:

P. I. Espina, T. T. Yeh, P. I. Rothfleisch, and S. A. Osella, ***"Tele-Metrology and Advanced Ultrasonic Flow Metering (updated version),"*** Proceedings of the International Conference on Metrology (Jerusalem, Israel: INPL 2000), pp. 137-147, and Proceedings of FLOMEKO 2000 (Salvador, Brazil: IPT 2000).

J. D. Wright and A. N. ***Johnson "Uncertainty in Primary Gas Flow Standards Due to Flow Work Phenomena,"*** Proceedings of FLOMEKO 2000 (Salvador, Brazil: IPT 2000).