15. Recent Developments in National Flow Standards.

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Objective: Develop a new generation of internationally recognized low-uncertainty flow metrology standards capable of responding to present and future U.S. industrial needs.

Problem: Since their establishment in the late 1960's and early 1970's, the standards of the NIST Fluid Flow Group (FFG) have only seen incremental upgrades. During the same period, a number of generations of flow sensors have been introduced into the market. Current leading technologies for flow meters have performance levels that challenge the uncertainty of U.S. standards. This places the American metrology community at a competitive disadvantage because they cannot claim uncertainties lower that those attained by our National standards while remaining traceable to NIST. Furthermore, National Metrology Institutes in other industrialized countries have recognized the importance of flow metrology standards to economic growth and have made large capital investments to upgrade their National standards. Examples of such facilities are the new state-of-the-art water calibration facilities in CENAM-Mexico and PTB-Germany, and the refurbished facility at NRLM-Japan; the natural gas calibration facilities of TransCanada Calibrations-Canada and Pigsar-Germany; and the new gas flow calibration facilities of IMGC-Italy and NRLM-Japan.

Approach: In the last five years, CSTL has mounted a programmatic effort to upgrade the flow standards of the Nation. As a result, most of our research effort has been focused on development of new methods to deliver improved flow traceability to the U.S. Economy. Areas that have seen upgrades are liquid density and volume, gas flow, and air speed. Areas that are undergoing improvement are natural gas flow metrology and water flow measurements. Liquid hydrocarbon flow metrology is an area earmarked for upgrade in the next year. Efforts have also been put forth to attain comparability of our standard with those of other countries through participation in activities sponsored by the Comité International des Poids et Mesures (CIPM) and our Regional Metrology Organization, Inter-American Metrology System (SIM).

Results and Future Plans: Liquid density standards were upgraded to yield uncertainties of about 4 ppm for distilled water determinations. This year, this improvement enabled us to certify two density SRMs: SRM 211d-Toluene (862.170 - 871.476 kg/m^3, ± 29 ppm), and SRM 2214-Iso-octane (687.753 - 695.969 kg/m^3, ± 51 ppm). Also this year, and in collaboration with a scientist from the Egyptian National Metrology Institute, our staff developed an automated gravimetric hydrometer calibrator. This new device, which is currently undergoing performance assessment testing, is expected to lower the uncertainty of hydrometer calibrations while reducing the testing time and cost. Similarly, we now offer liquid volume calibrations with traceability for contained volumes of 50 ppm and 200 ppm for delivered volumes. In air speed, we are now capable of delivering traceability with uncertainties as low as 0.006 m/s.

In the area of gas flow metrology, the FFG has been working n a new gas flow standard. When completed it should enable calibration of flowmeters with uncertainties of 0.05% of reading (a 4x improvement from our present level of 0.2%) in the range from 0.1 to 1,600 standard liters per minute (slm). This year, our efforts were focused on the reduction of the significant uncertainty associated with amount of gas contained in the connecting volume between the meter-under-test and the collection vessel. A new thermodynamic model of this subsystem was developed and its results led to significant design improvements and more complete uncertainty estimation. Our large gas flow metrology facility also saw major renovations with a replacement of its pressure and control instrumentation and the addition of new pipelines as large as 250 mm.

Efforts towards the addition of a natural gas flow calibration capability continue through our partnership with the Colorado Engineering Experimental Station, Inc. (CEESI, an American secondary metrology laboratory) and Daniel (a flow meter manufacturing division of Emerson Electric Company and a member of the Fisher-Rosemount group). Details of this effort can be found in the next report "Tele-Calibrations and Advanced Ultrasonic Flow Metering".

Prompted by request from the DoD Calibration Coordination Group, the FFG decided to initiate an effort to commission a set of piston-type hydrocarbon flow calibration standards. These facilities will make use of MIL-C-7024C fluid (sometimes called Stoddard solvent), which is a surrogate liquid for JP-4 and JP-5 jet fuels. The facilities will operate in the range from $3.5x10^{-2}$ to 1,500 liters per minute, with target uncertainties of 0.025% of reading. These facilities are expected to be operational by the fall of 2002.

Publications:

V. E. Bean and J. F. Houser "***Characterization of Iso-octane as a Liquid Density Standard SRM 2214",*** SRM Report of Analysis (Gaithersburg, MD: NIST 2000).

V. E. Bean and J. F. ***Houser "Characterization of Toluene as a Liquid Density Standard SRM 211d",*** SRM Report of Analysis (Gaithersburg, MD: NIST 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).