7. Calibration and Test Services Provided by the Process Measurements Division

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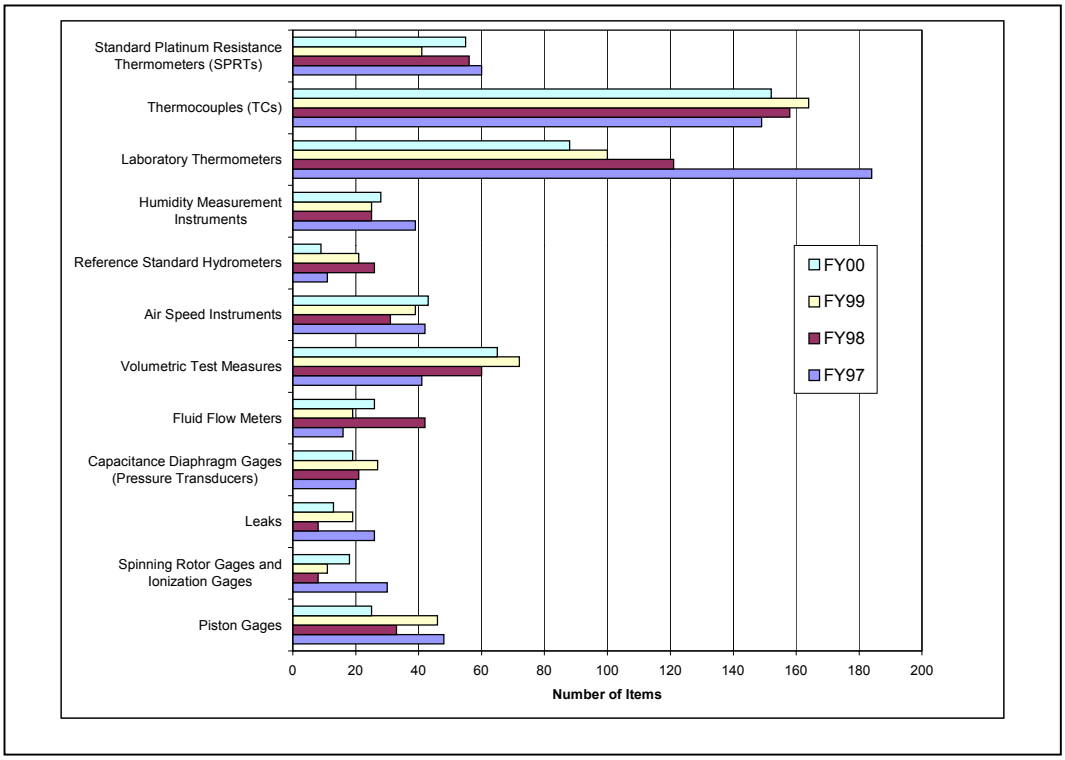
Objective: To realize and maintain national standards according to the definitions of the relevant units, and to disseminate the NIST-realized units to industry and government agencies (federal and state governments) that require calibrations against, and direct traceability to, national standards.

Problem: The Process Measurements Division is responsible for realizing, maintaining, and disseminating the national standards for measurement of temperature (in the range of 0.65 K to 1235 K), pressure, vacuum, gaseous leak rate, humidity, fluid flow rate, liquid volume and density, and air speed. Issues of primary importance in this area involve:

- assessing and meeting, to the extent practicable, customer requirements in terms of types and ranges of service and levels of uncertainty,
- improving the efficiency of calibration services,
- developing methods to enable appropriate realization of standards in the customer's laboratories,
- serving as a primary resource supporting the national measurement system, and
- participating in the international programs to establish and maintain the equivalency of the standards in National Metrology Institutes (NMIs) to eliminate measurement-based barriers to trade.

Approach: Provision of customer-appropriate access to national standards of measurement involves a range of activities: maintenance and improvement of primary standards, participation and leadership in U.S. and international standards activities, performance of instrument calibrations and tests, operation of Measurement Assurance Programs (MAPs), proficiency and round-robin tests, development of mechanisms for realization of secondary standards in customer laboratories, and a wide-range of consultation and customer assistance services. The calibration and test services provided by the Division are described in NIST SP 250, NIST Calibration Services Users Guide, and its supplements.



Results and Future Plans: The chart above summarizes the level of activity in each service. Large fluctuations, year to year, in numbers of items are often encountered; however, the total calibration workload typically varies by less than 20%. Our capabilities, experimental techniques and the facilities used to provide these services are continually upgraded, with concomitant improvements in efficiency and in measurement uncertainties. Improvements of standards and highlights of activities for temperature, humidity, and gas flows are discussed in separate reports below. Also presented in separate reports are descriptions of our extensive involvement in the CSTL International Measurements Standards Program, a critical element in maintaining the position of the Nation's measurement system in the world.

During the past year, we have continued to improve the NIST-generated, web-based Information System to Support Calibrations (ISSC). This system significantly increases our abilities to monitor progress and assess results in our numerous and diverse calibration services. It also enables efficient archiving of the data for the instruments calibrated and the efficient inclusion of these results in future reports of calibration to show instrument owners their historical records and to quantify the temporal stability of the uncertainties claimed. The ISSC also enables our calibration customers to access the status of their calibrations with password-protected security. Since the ISSC has been in operation, our calibration delivery records show increasing percentages of results completed on time or early and our averages for days late decreasing by more than 35%. Additionally, the ISSC has received numerous compliments from NIST calibration customers.

In FY00, the Humidity Project of the Thermometry Group began development of a modern humidity generator system to replace the existing two-pressure humidity generator (2PHG) system. The new system will have a lower uncertainty, an expanded operating range, the capability for automated operation, a smaller footprint and improved efficiency and safety. The new standard humidity generator will have a thermodynamic basis similar to that of the 2PHG and the Low Frost-Point Generator (LFPG) systems. However, we will incorporate advances in flow control/measurement technology into the design, and thereby perform controlled dry-gas dilution of the streams exiting the saturator. The humidity level of a gas mixture is quantified in terms of an amount of water vapor per amount of dry carrier gas (typically air or nitrogen). By saturating the carrier gas with water vapor at a well-defined temperature and pressure, the fraction of the water vapor in the gas phase can be predicted from first principles. In the new system, we will saturate the carrier gas at only a few selected temperatures with the saturator nominally at atmospheric pressure. At each saturator temperature, diluting the saturated stream with a known quantity of dry gas will vary the humidity level. It is expected that in the frost-point temperature range 80 °C to 0 °C the maximum uncertainty will be less than 35 mK in dew-point temperature or 0.35 % in water vapor mole fraction.

In May, 2000 NIST convened a workshop on mass flow measurement and control for the U.S. semiconductor industry to learn what NIST can do to improve productivity in this important industrial sector. Attendees included flow metrologists and experts from industry, government, and academia. In an efficient and effective format, brief topical overviews were presented and subgroups were formed to focus productive discussions on flow meter performance, standards and calibration, gas properties, and alternatives to thermal mass flow controllers. The five major recommendations to NIST were:

1. increase the range of our flow transfer standards,
2. improve the uncertainty of our primary and transfer standards,
3. expand and reprioritize our list of gases for thermophysical property determinations,
4. maintain a publicly-accessible web-based database of such properties, and
5. develop metrology to characterize liquid flow controllers.

These recommendations now form the basis for new and ongoing work in the division's corresponding program areas.

In response to industrial and other government agency requests, we have just initiated a round-robin comparison of vacuum leak-measurement capabilities under the auspices of NCSL International - formerly known as the National Conference of Standards Laboratories. We are finalizing the list of participants, working on protocol development, and expect to begin circulation of the transfer standards (i.e., calibrated leak artifacts) in FY2001. Experiences gained in performing this comparison

are expected to pave the way for similar activities in conjunction with our efforts fulfilling commitments for the International Bureau of Weights and Measures (BIPM), the International Committee on Weights and Measures (CIPM)/ the Consultative Committee on Mass and Related Quantities (CCM), and for the Regional Metrology Organizations (RMOs).

We have begun the development of a new primary pressure standard that should reduce NIST's expanded uncertainty in the near atmospheric to 1 MPa pressure range by a factor of 4-5, to possibly below 5 ppm. This new standard is a low-pressure gas piston gauge whose piston and cylinder components were very precisely dimensioned, thus allowing an extremely accurate determination of the gauge's effective area – which is a direct measure of the pressure it generates. Prior to this dimensional technique, this gage was calibrated against other NIST pressure standards resulting in ~19 ppm uncertainty for this transfer standard (due to traceability from another primary pressure standard). Validating tests will be completed in FY2001 prior to commissioning of this new standard.

A new hydrostatic method for the calibration of liquid hydrometers has been implemented by the Fluid Flow Group. The previously used calibration method places a reference hydrometer and the hydrometer under test in various liquid mixtures having different densities. The new method uses only distilled water and measures the force applied to a weigh scale when the hydrometer is immersed to different depths. The new hydrostatic weighing method is expected to reduce the uncertainty of hydrometer calibrations to 1/5th of that quoted previously. It is also expected to improve the time efficiency of the calibration service dramatically. Comparisons between the two methods are currently underway and the new approach should be available to customers in FY2001.

The Fluid Flow Group has designed and initiated the refurbishment of our large water flow measurement standards and the completed facility is to be re-commissioned in 2001. The characterization of the refurbished capability will be used both for NIST's Quality Manual documentation of these standards and the preparation of its CMCs. The schedules for these efforts should enable NIST to participate in the KCs for water flow.

In FY 2000, the Division has initiated a succession of audits for the Quality Manuals for each of its calibration services. These Manuals constitute the bases for our maintenance of our measurement standards as well as the description and declarations of uncertainties in our Calibration and Measurement Capabilities. Our planned succession is to use the National Voluntary Laboratory Accreditation Program to assist, initially, in these audits followed by NIST metrologists from other calibration areas. Ultimately, we will arrange our own panel of metrological experts to conduct a peer review of our calibration service activities to culminate the first round of review of the Division's Quality Systems in 2001.

Publications:

Berg, R.F., Green, D.S., Mattingly, G.E., ***NIST Workshop Report: Mass Flow Measmurement and Control for the Semiconductor Industry;*** 27 pgs. (2000).