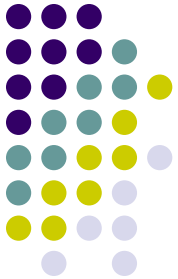
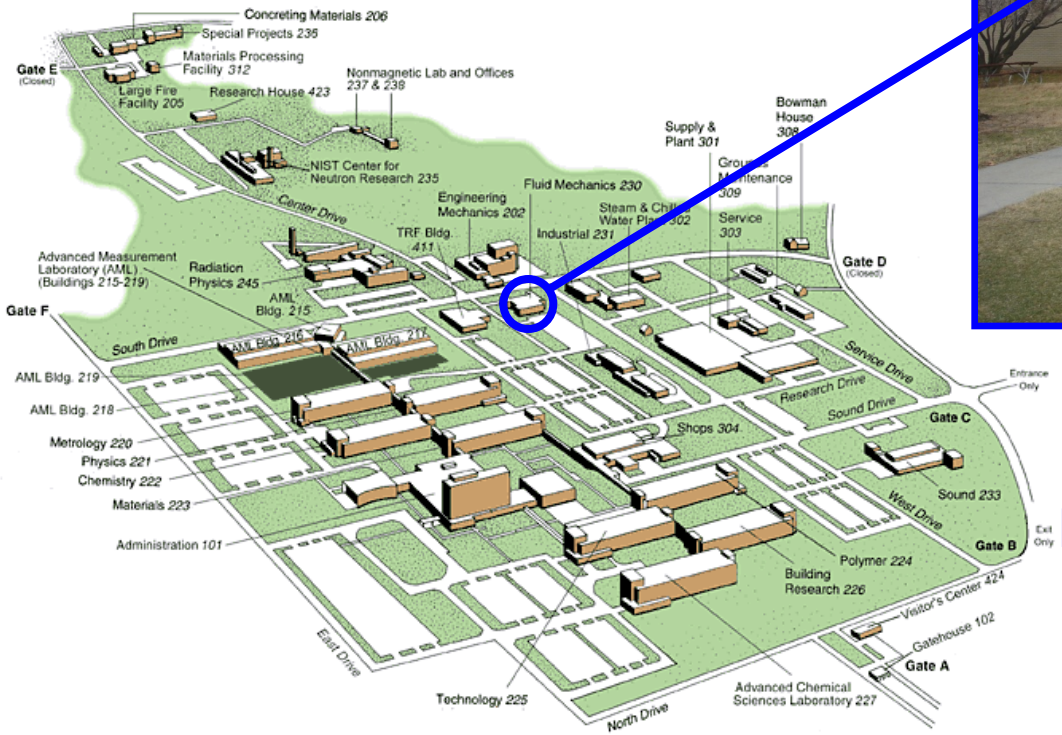


# NIST Fluid Metrology Group

# NIST Gaithersburg Campus

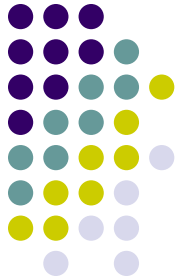




## Fluid Mechanics Building

- Building built 1967
- Staff
  - 4 Researchers
  - 3 Technicians
  - 2 Guest Researchers

# Fluid Metrology Group (FMG) Mission

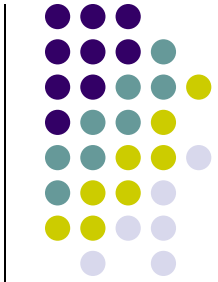


1. To provide calibration services for fluid flow, airspeed, liquid density and volume measurements.

2. To develop models, reference data, and novel techniques for improved measurements of flow, temperature, and pressure.

3. To determine the thermodynamic and transport properties of process gases

# FMG Calibration Services



- Gas Flow Standards
- Liquid Flow Standards
- Air Speed
- Hydrometers (Liquid Density)
- Liquid Volume
- High Pressure Natural Gas

# Small and Medium *PVTt* Standards

- **Small PVTt Standard has a 34 L Collection Tank**

- **Medium PVTt Standard has a 677 L Collection Tank**

## Flow Capabilities

Flow Range: 0.001 – 2000 L/min  Line Pressures: 0.1 – 7 MPa

Computer Automated  Ambient Temperatures

**Expanded Uncertainty = < 0.025 % ($k$ = 2)**

# Large *PVTt* Gas Flow Standard

## Flow Capabilities

### Dry Air

**Flow Range: 862 to 77600 L/min**

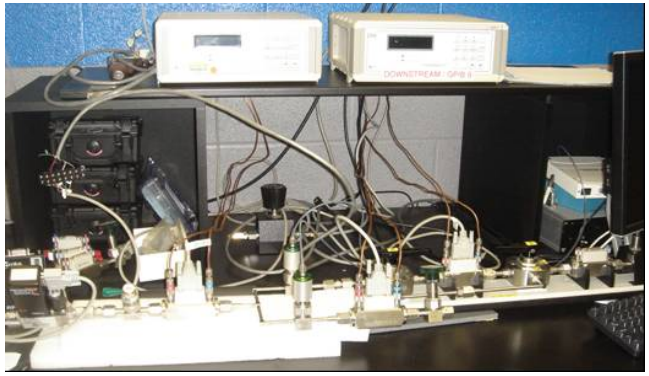
**Line Pressures: 150 to 850 kPa**
**Ambient Temp.**

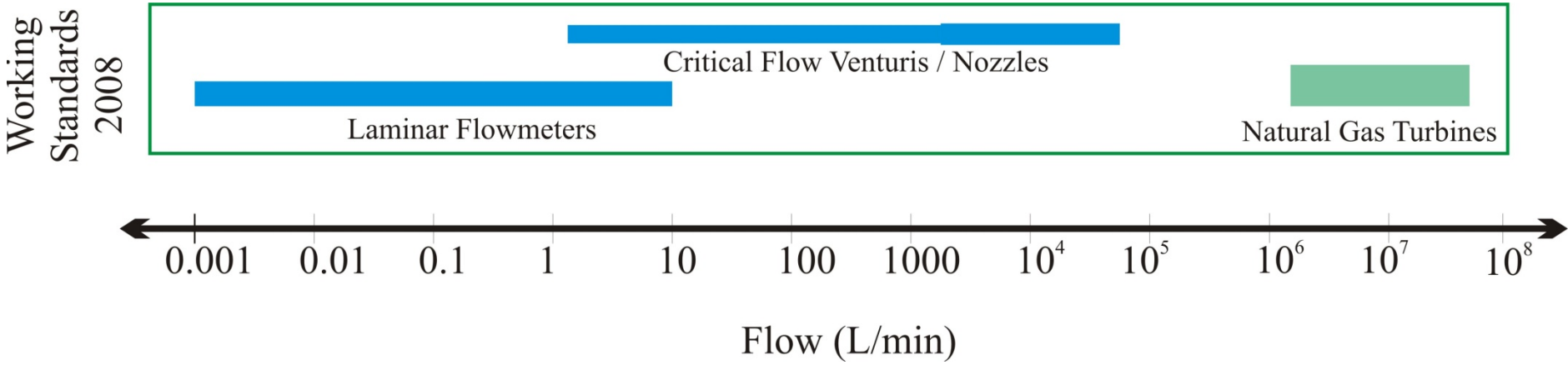
**Fully Automated (LabView)**

**Expanded Uncertainty =**
**0.09 % (*k* = 2)**

# Working Gas Flow Standards

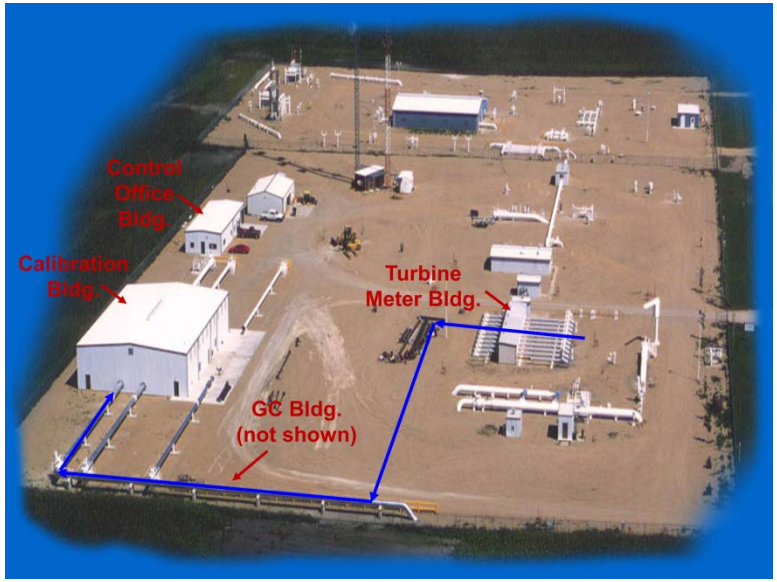
Working standards cover 0.001 to 77600 L/min
with uncertainty of 0.08 % to 0.16 %





# NIST Natural Gas Flow Calibrations (at CEESI Iowa)

**Flow Range: 0.25 to 9 $m^3/s$** **Unc = 0.24 to 0.35 % ($k$=2)**




**Turbine Meter Standards (TMS)**

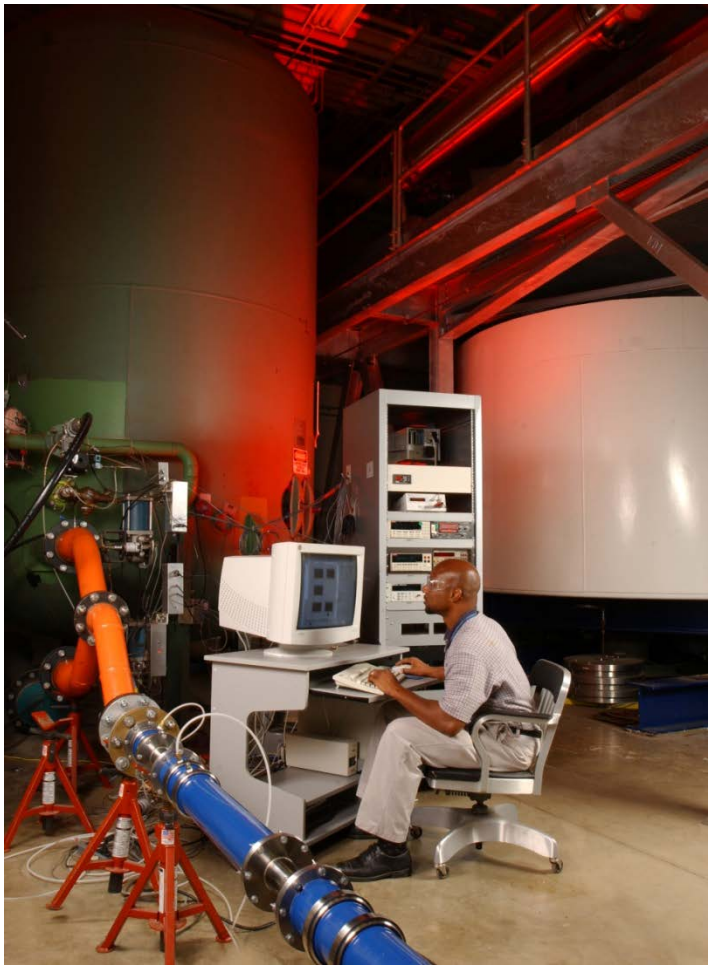
**Test Section**

# Natural Gas Flow Measurements

**Traceable to NIST 26m³ *PVTt* standard**

**Flow Range: 0.25 to 9 m³/s**

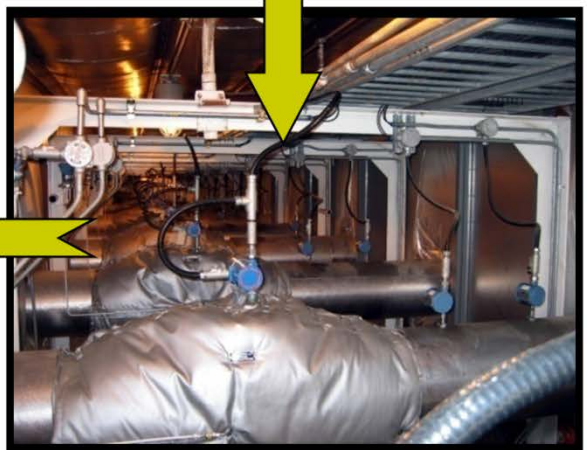
**Expanded Uncertainty = 0.24 to 0.35 % (*k*=2)**



Low Pressure
Air Flow Standard
26 $m^3$ *PVTt* Std.

CFV Bootstrap
(Pressure scale-up in Air)


High Pressure
Natural Gas
Calibrations



Turbine Meter Working
Standards (TMWS) in
Natural Gas

# Water Flow Calibration Facility (65 kg/s LFS)

**Flow Range: 36 – 3900 L/min**

**Line Pressures: 0.1 – 1 MPa**

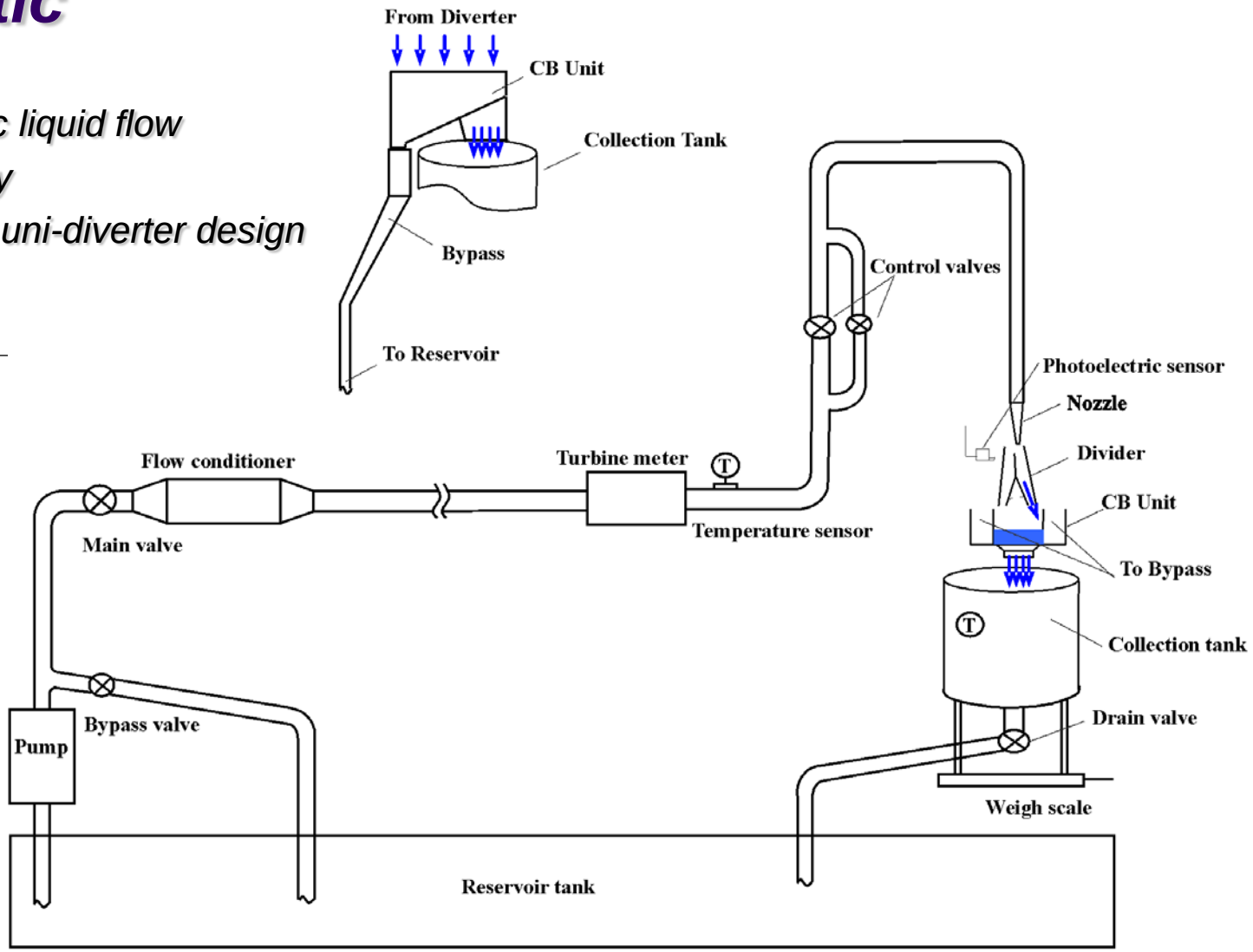
**Pipe sizes: 2.5 – 20 cm**

**Expanded Uncertainty = 0.033 % ($k$ = 2)**

# NIST 65 kg/s Liquid Flow Calibration Facility (LFCF)

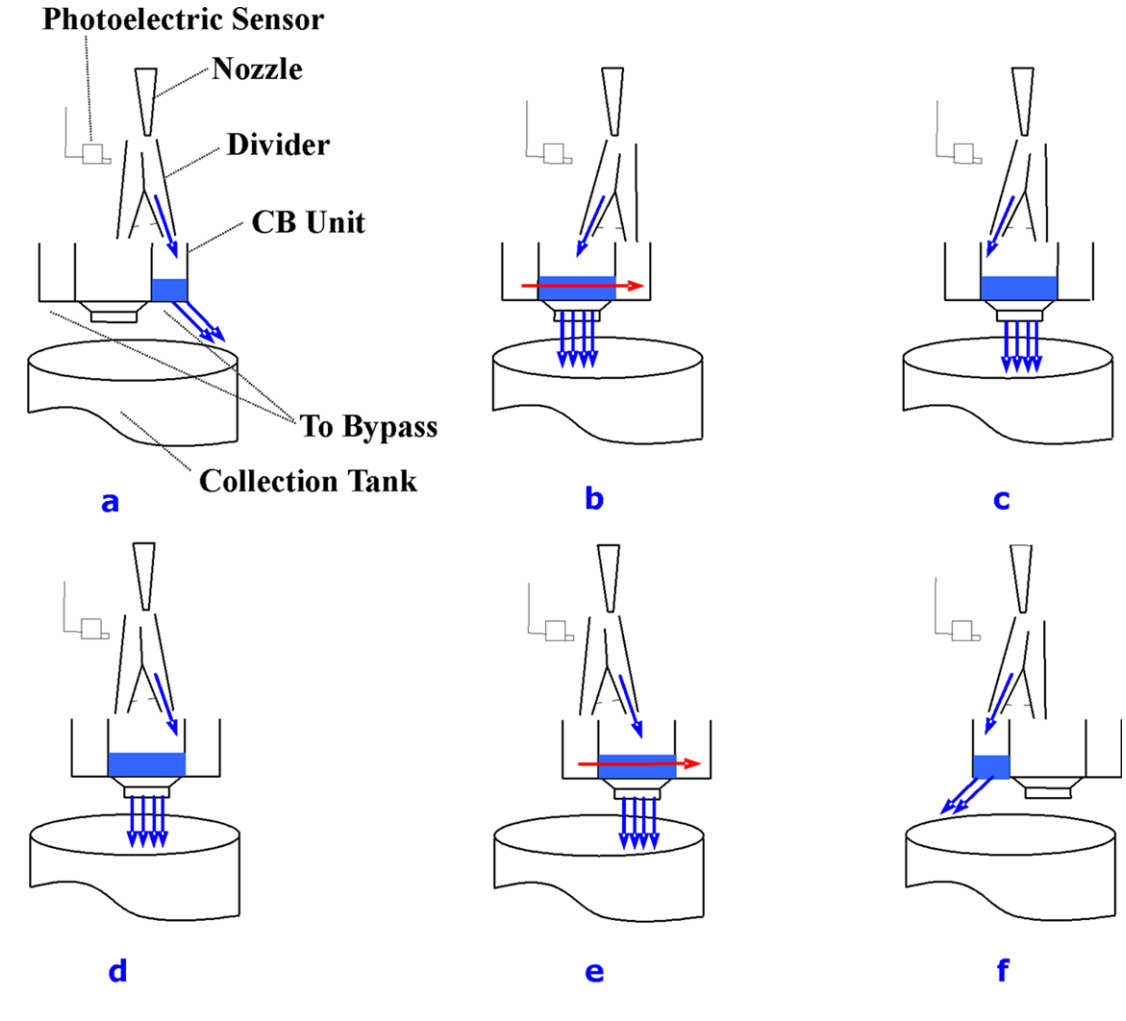
## *Schematic*

- *Static-gravimetric liquid flow calibration facility*
- *Incorporates the uni-diverter design*




- Flow range: 0.6 kg/s – 65 kg/s for static method and 0.06 kg/s – 65 kg/s for dynamic.
- Weigh Scale Capacity: 4500 kg with 10 g resolution

# Uni-directional Diverter Operational Sequence




Diverter Error is Self-Canceling

Flow Stability Required

DEMO Diverter_1.MPG

# Liquid Flow Standards

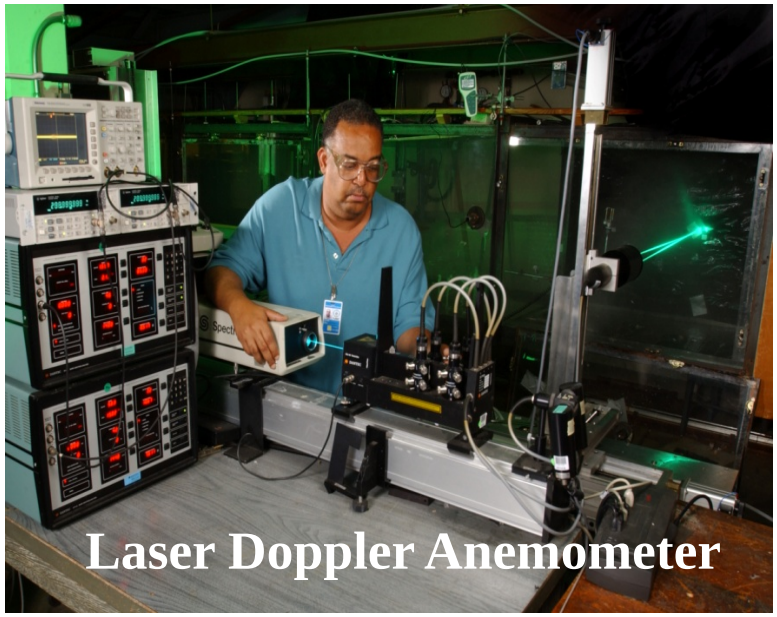
## Flow Capabilities

- Fluid: Propylene Glycol & water
- Flow Range: 0.19 – 120 L/min
- Temp. Range: 22°C ± 0.5°C
- Line Pressures: 0.1 – 0.2 MPa
- Pipe sizes: 0.17 – 1.3 cm
- Expanded Unc.: 0.05 - 0.07 % ($k$ = 2)

**2.5 L/s LFS piston prover**

**0.1 L/s LFS piston prover**

# Air Speed




- Recirculating wind tunnel
- Laser Doppler Anemometer (LDA)
- Spinning disk used to calibrate LDA

- **Velocity range:** 0.15 m/s to 75 m/s
- **Uncertainty =** $2\sqrt{(0.0032\,U)^2 + 0.0018^2}$ m/s

# Liquid Volume Calibration Service

- Volume Range: 5 to 1900 L

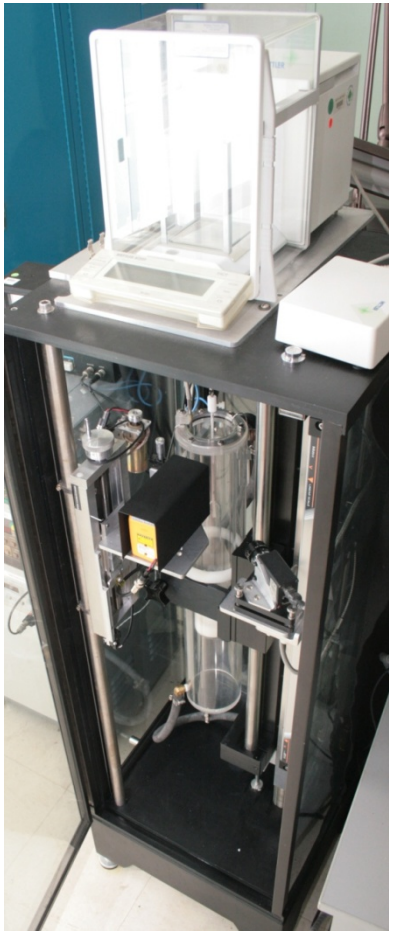
**Uncertainty =**

$$\left(0.012 + 0.00015\,V\right)\mathrm{L}$$

**Liquid volume**

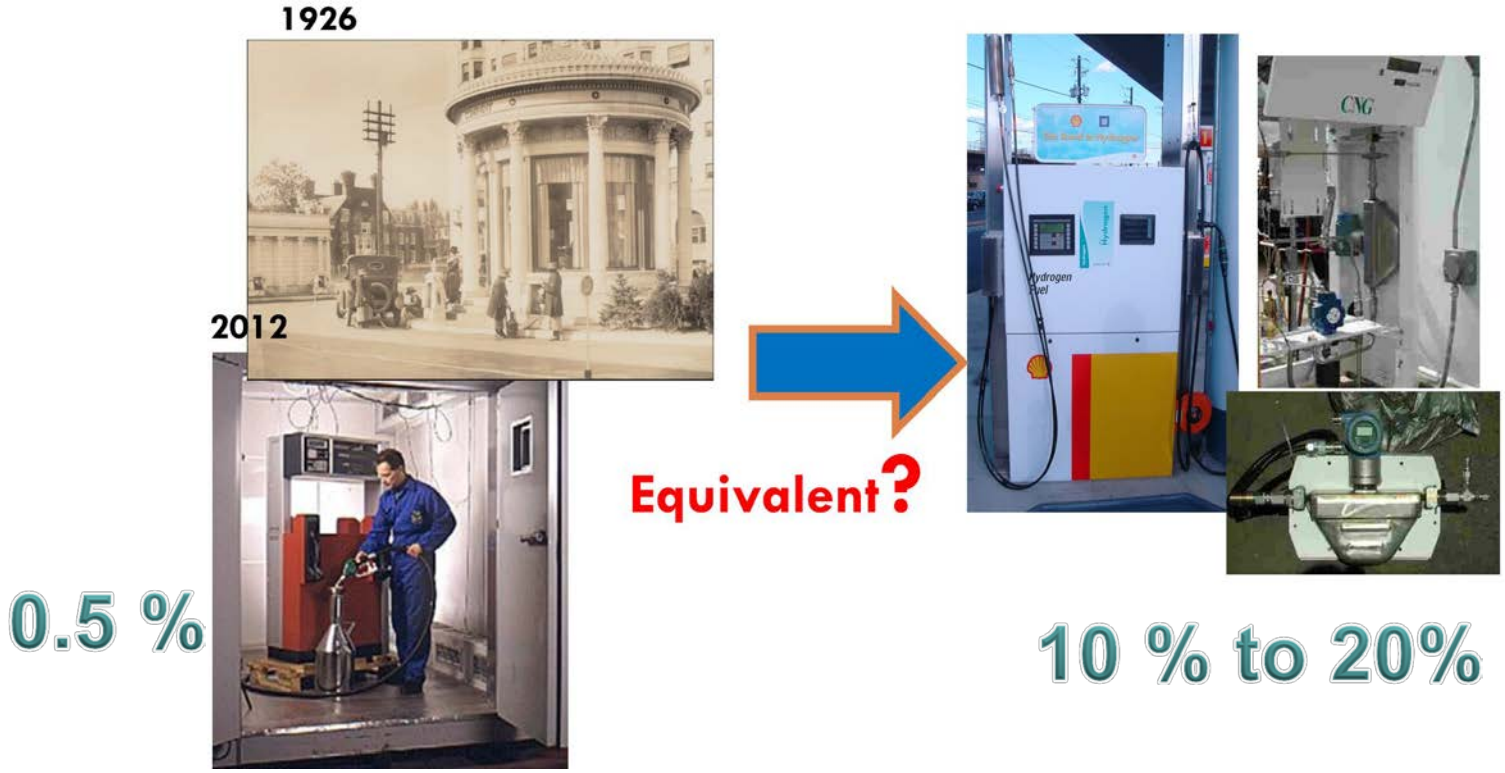
# Hydrometer Calibration Service

- **Liquid Density Calibration**
  - Hydrometer: instrument used to measure liquid density
  - Calibration Range: 0.6 to 2 g/cm$^3$
- **Liquid Density Primary Standard**
  - Gravimetric hydrometer calibration system
  - Expanded Uncertainty: 0.01% ($k$ = 2)



# FMG Research

- Transient Flow Facility (TFF)
  - **Evaluation of meter performance in gaseous dispensers.**
  - **Evaluation of gaseous refueling field test methods.**



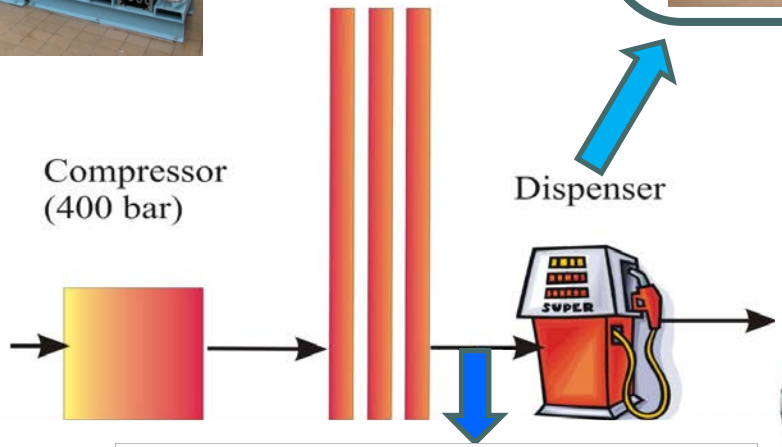
# Facility Design

## Source/Cascade Tube Bank

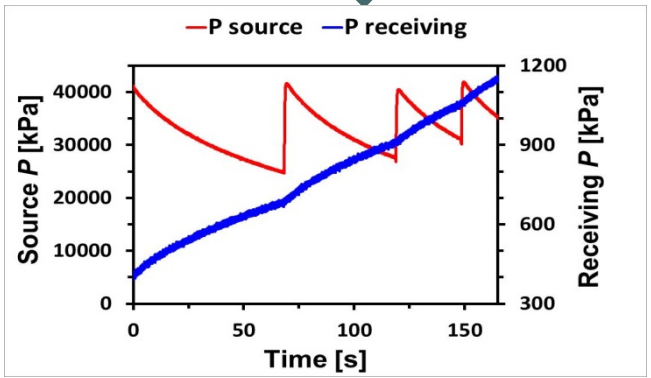
### Compressor

Cascade tube bank

### Test Bed




"Receiving vessel"
25, 35, 70 MPa

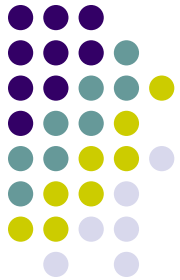



### Receiving Vessel

# FMG Research

- NIST Smokestack Flow Measurement Program
  - Quantifying Greenhouse Gas Emissions from Power Plants

# Meeting Flow Measurement Needs (Improving $CO_2$ Measurement Capabilities in Smokestacks)



- Assessing carbon mitigation efforts and/or implement future carbon controls (*e.g.*, carbon tax, cap and trade) requires accurate measurements of the $CO_2$ flux emitted by coal-burning power plants

- Errors in current $CO_2$ flux measurements (based on EPA protocols) may be **as large as 10 % to 20 %**

- NIST Objective: $CO_2$ flux measurements with **1 % uncertainty** at a reasonable cost

# Smokestack Flow Measurement Challenges

**Measuring flow in stacks is very different**

**Problems include:**

- No lab can calibrate a 10 meter pipe
- Pipe area is not accurate
- Dirty, moist gas.
- Variable temperature and densities
- Flow is very different, usually swirling
- Flow is often changing during RATA (Relative Accuracy Test Audits)

# NIST Smokestack Simulator

- Facility to research flow meters and profiling methods used in smokestacks
- **“L” shaped, 1.2 m diameter test section**
- **Velocity in Test Section**: 6 to 25 m/s
- **0.5 % flow uncertainty** from reference flow meter
- Various distorted profiles possible in test section