EASTMAN

Improved Pressure Drop & Ventilation Instrument with Variable Flow Rates

Steven A. Wilson
Eastman Chemical Company
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Objective

- Replace pressure drop and ventilation (PDV) instrument.
- Develop an instrument that can operate over a range of flow rates.
- Utilize the up-to-date low flow control systems and measurement technology.

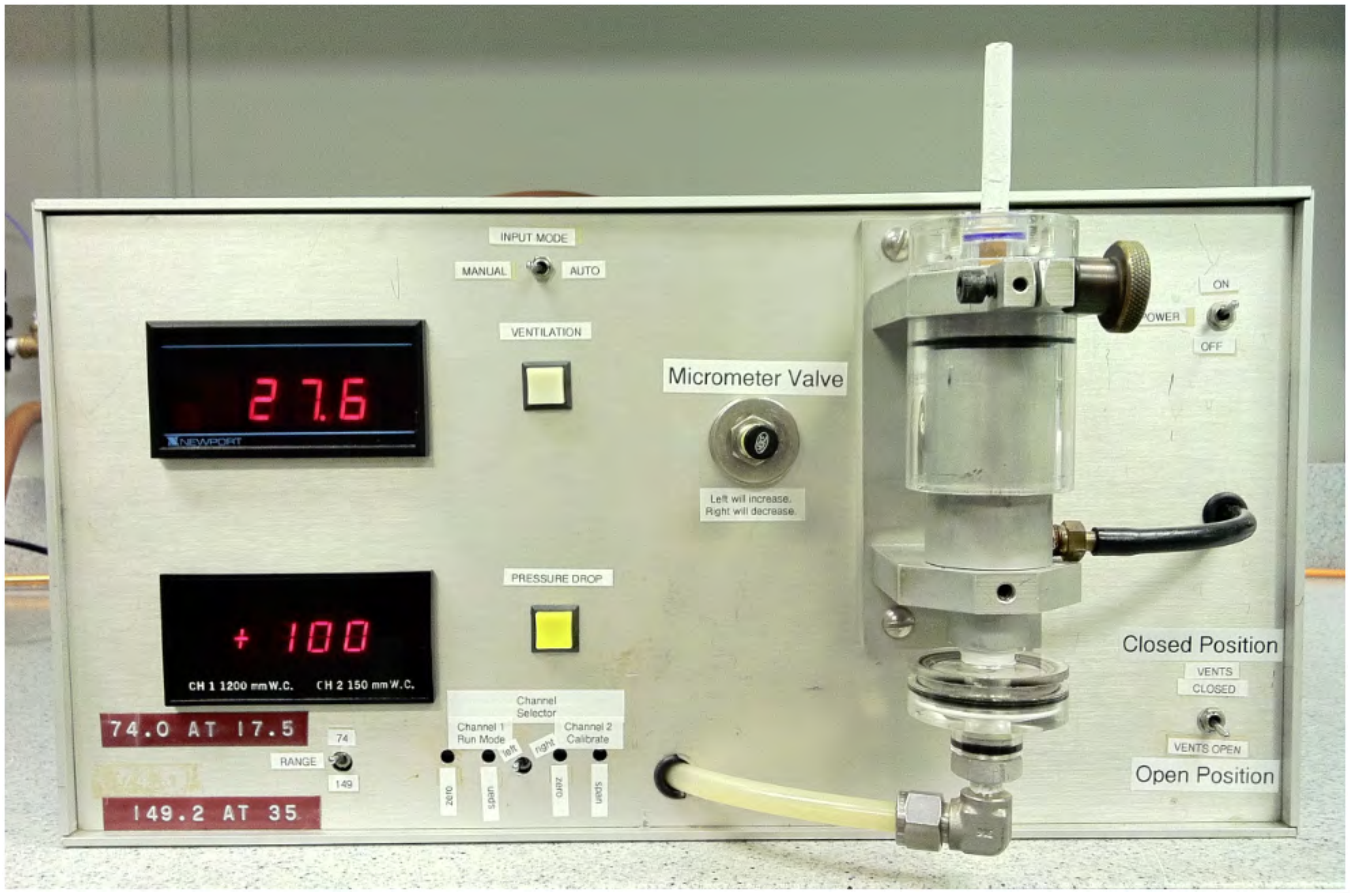
Why the replacement?

- Need to upgrade testing equipment
- Need to measure tip pressure drops & filter ventilation at various flow rates/puff volumes
  - Various smoke testing standards
  - Increased regulatory environment
  - Tighter quality control

Comparison of smoking conditions

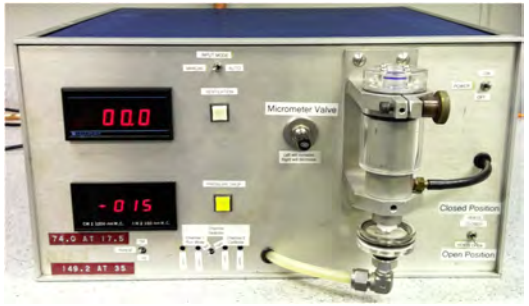
	Puff volume (ml)	Puff duration (sec)	Puff interval (sec)	Ventilation blockage (%)	Mean flow rate (ml/s)
ISO	35	2	60	0	17.5
Massachusetts Intense	45	2	30	50	22.5
Canadian Intense	55	2	30	100	27.5

Previous research instrument

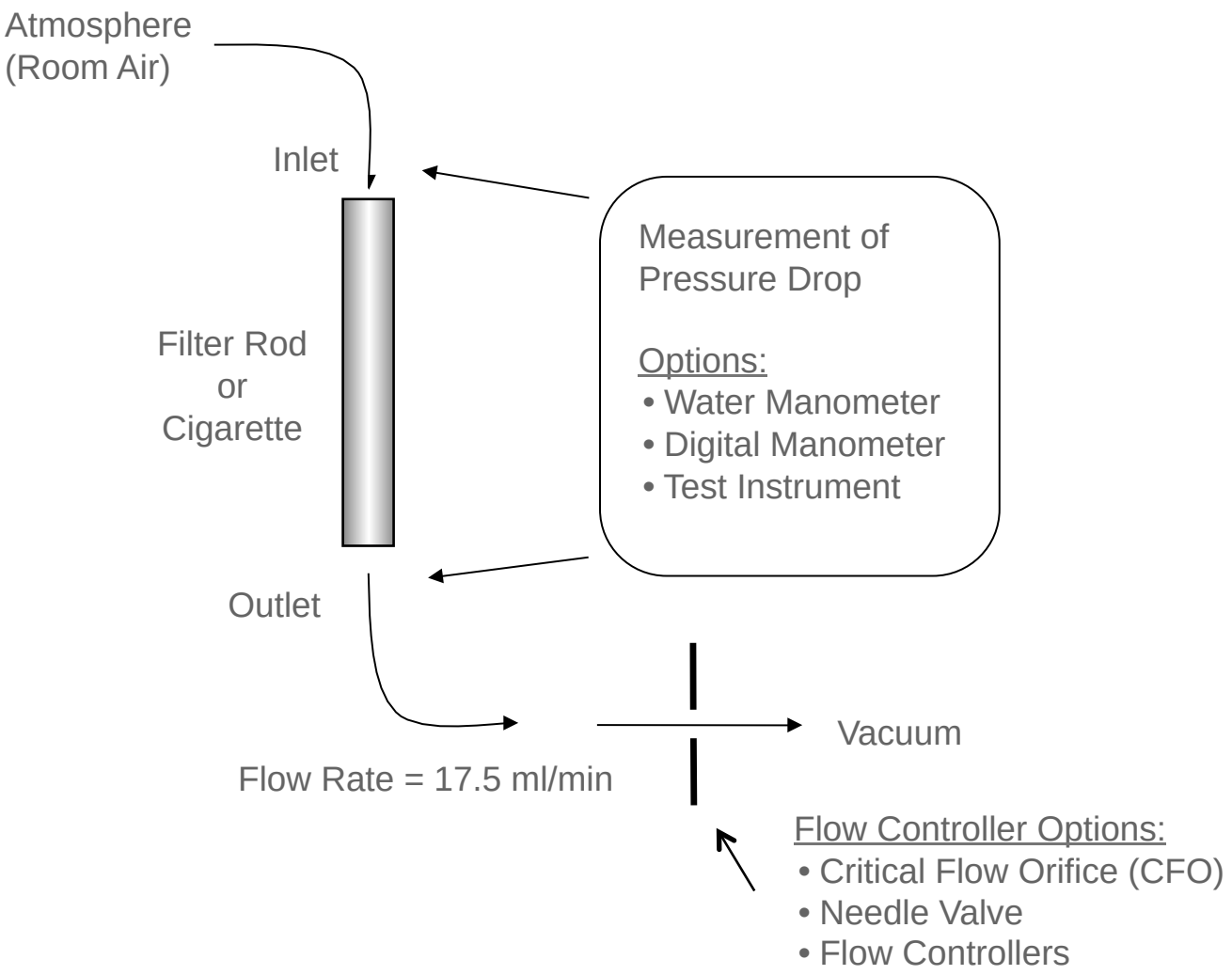


Features of previous PDV instrument

- Design and built in 1980
- Flow rate = 17.5 ml/min
- Flow adjusted with a micro metering value and controlled by measuring the pressure drop though a Meriam laminar flow calibration standard
- Pressure drop measured by a Validyne differential pressure cell sensor
- Ventilation air-flow measured by a Kurz air-flow meter
- Dot matrix printer



Basic pressure drop instrument diagram



Comparison of flow controllers

- Critical flow orifice
  - Non adjustable
  - Inaccurate
- Needle valve
  - Allows adjustments
  - Need to calibrate
- Flow Controllers
  - Pneumatic vs. electronic control
  - Flow rate check versus calibration
  - Environmental influences
    - Temperature
    - Relative humidity
    - Atmospheric pressure

Custom Electronic Systems, Inc. (CES)

- Corporate expertise
  - Specializing in low air flow measurement and control
  - In business for over 30 years
  - Located in Rural Hall, North Carolina

- CES has previously developed research instruments for the tobacco industry
  - Model CES 209 Flow & Totalizer
  - Model CES 228 Filter Size Controller
  - Model CES 237 Flow & Volume Indicator
  - Model CES 280 Flow Controller

Features of new PDV instrument

- Designed and built in 2010
- Flow rate of up to 100 ml/sec
- Pressure drop range of 0 – 1000 mm H_2O
- Ventilation range of 0 – 100 %
- Flow rates measured with two laminar flow elements
- Microprocessors allowing real time measurement of air flow rates
- Auto zero compensation for room temperature, relative humidity, barometric pressure, and vacuum levels
- Various circumferences possible (by changing seals)

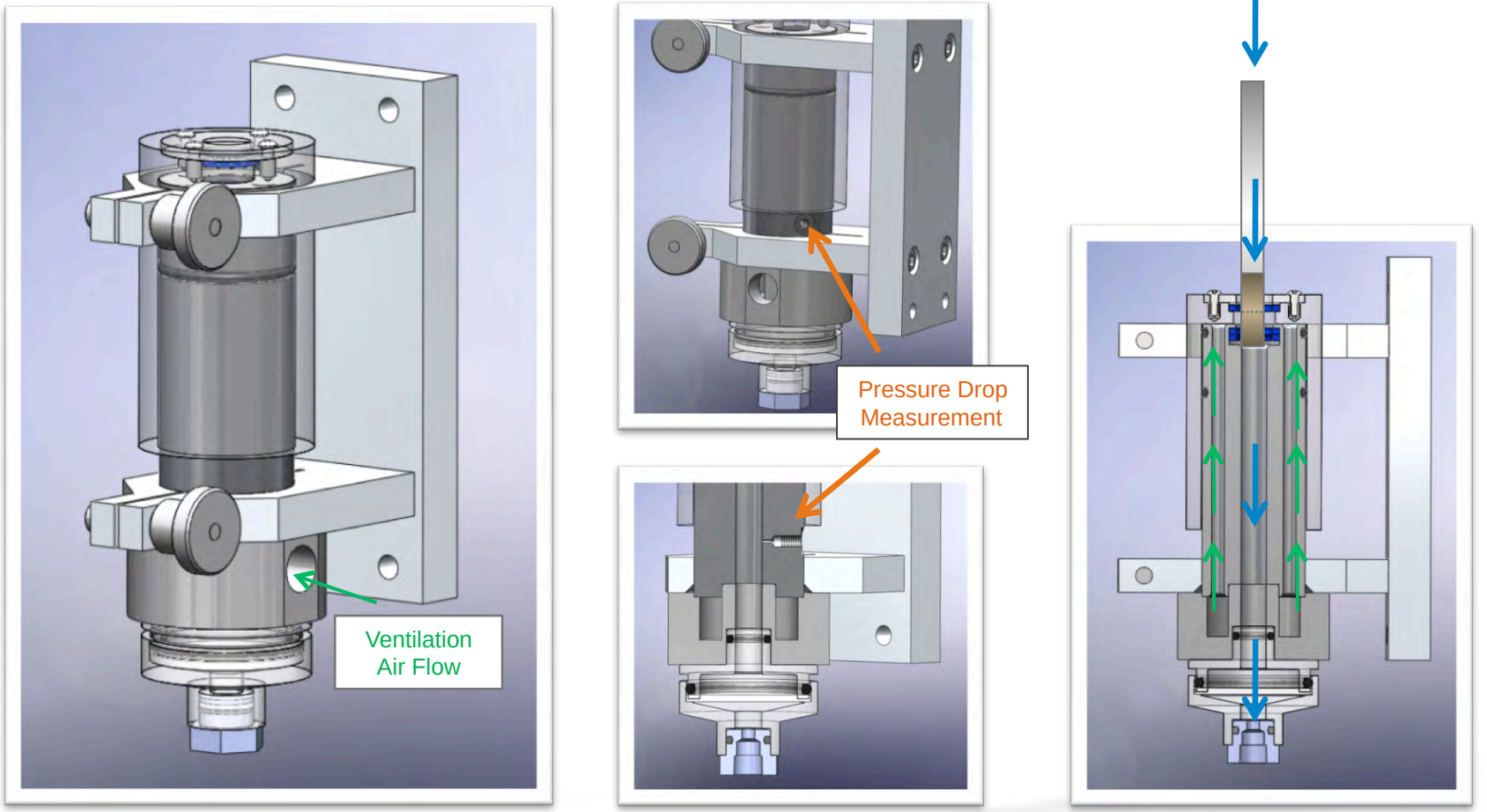
CES 508 Instrument

Sample holder

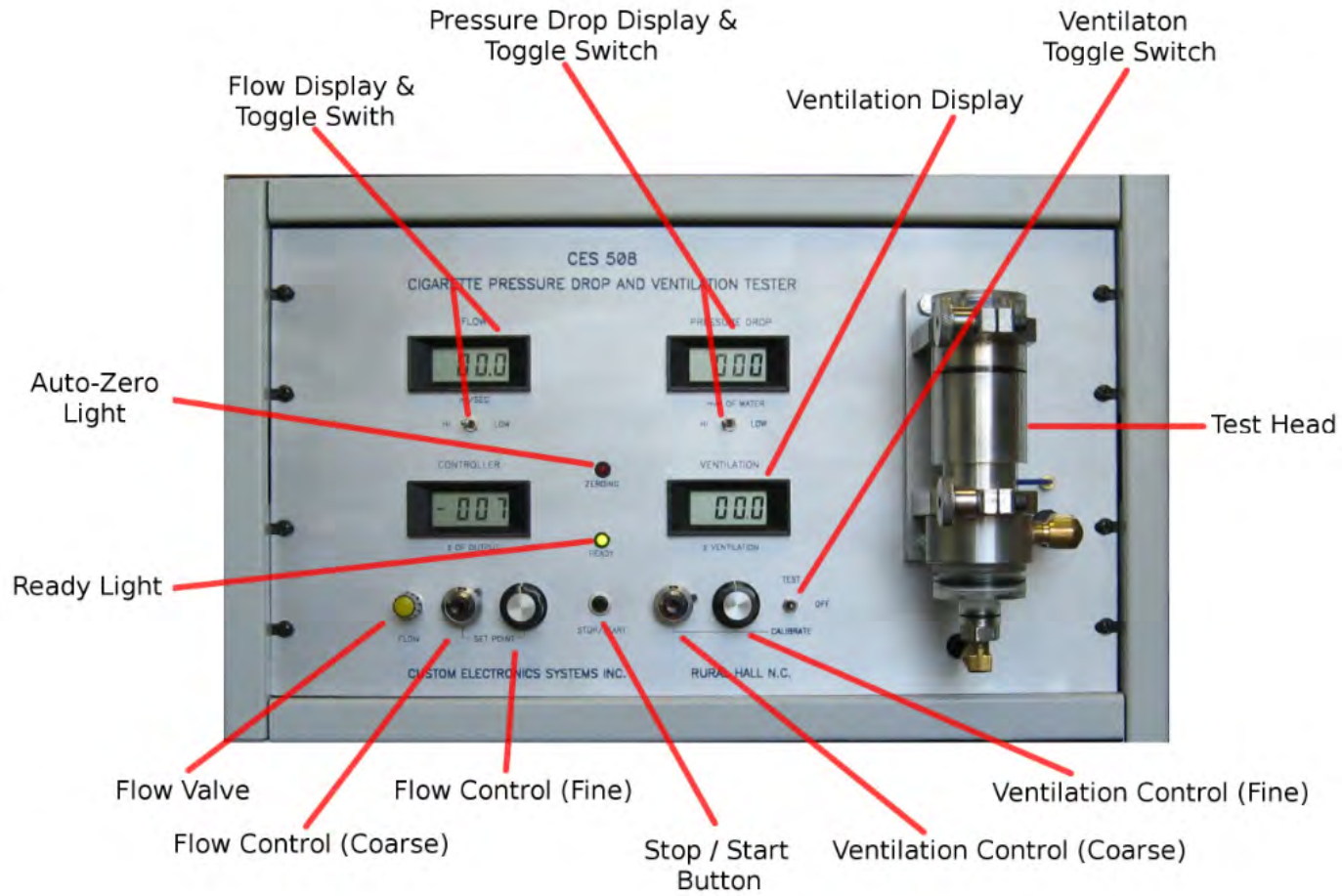
Previous Holder

New Holder

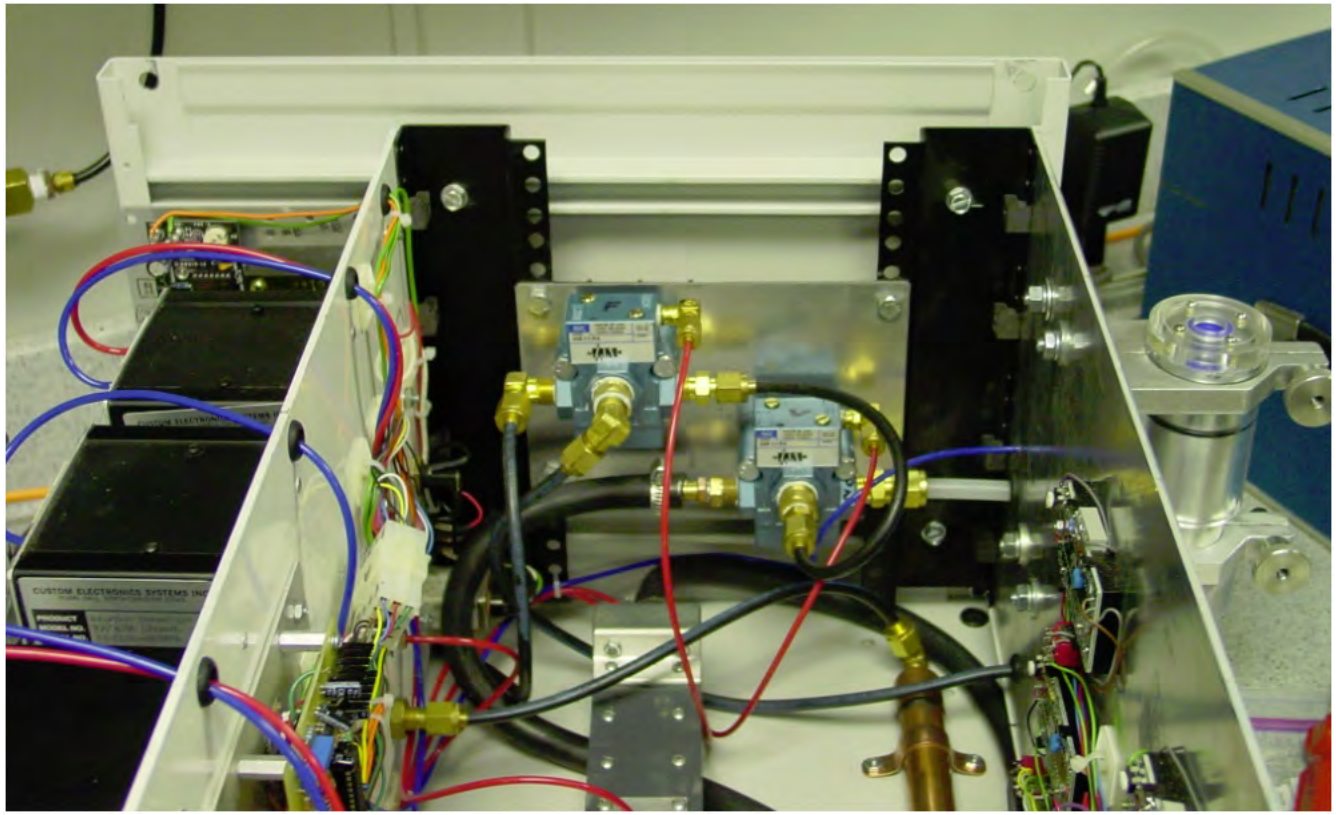
Design of sample holder



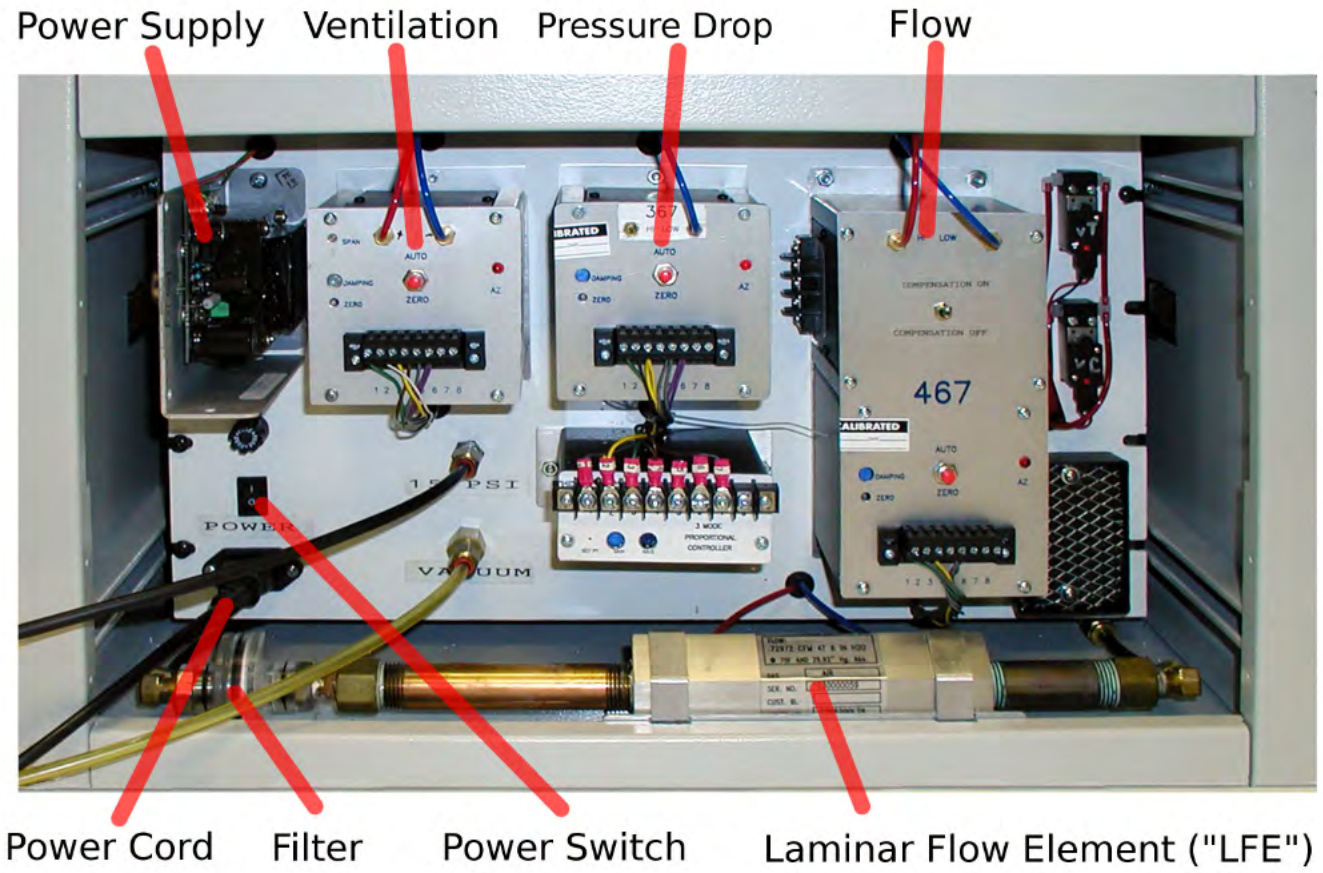
CES 508 - front panel



CES 508 - inside sections



CES 508 - back panel

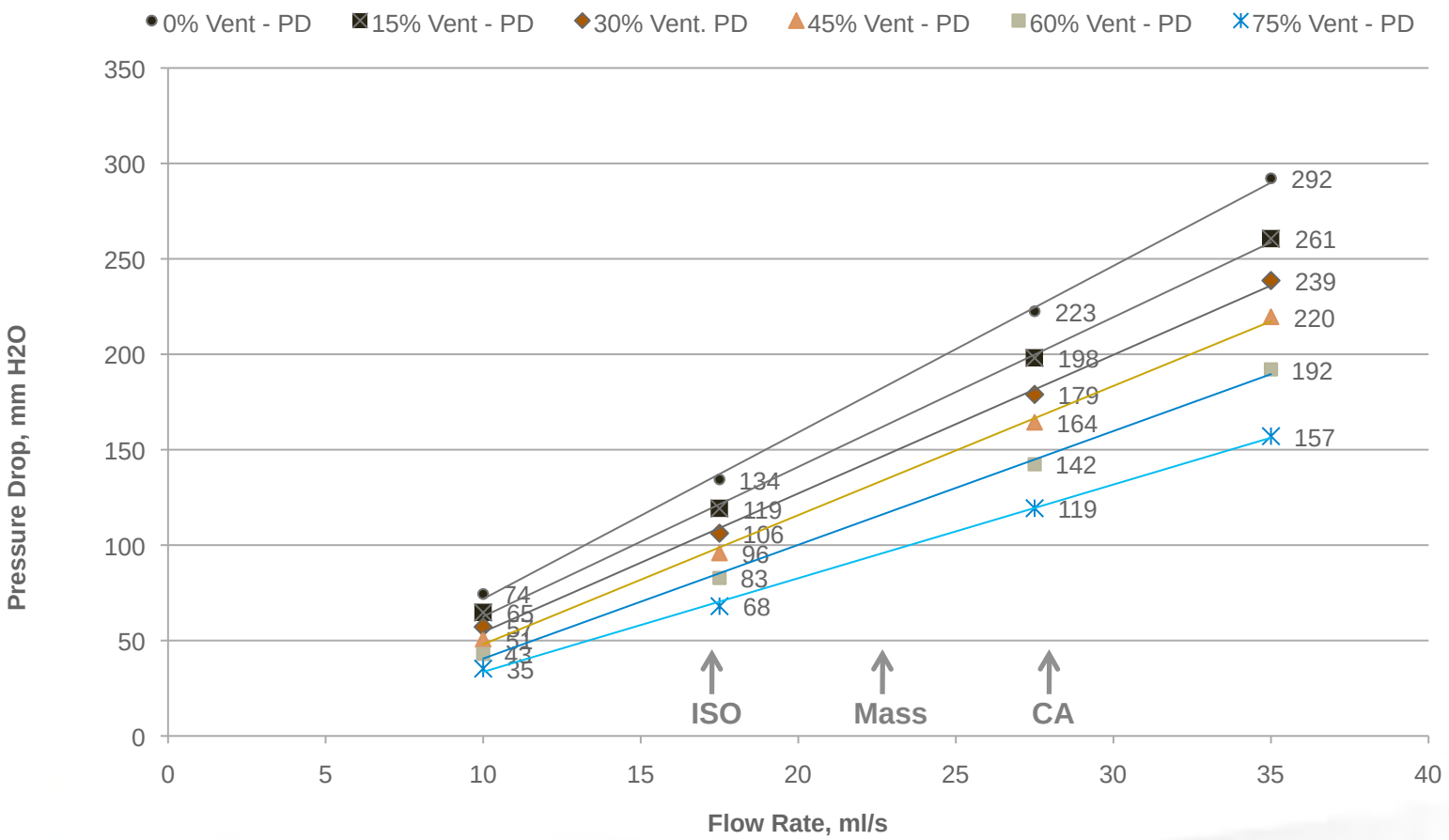


Ventilation series experiment

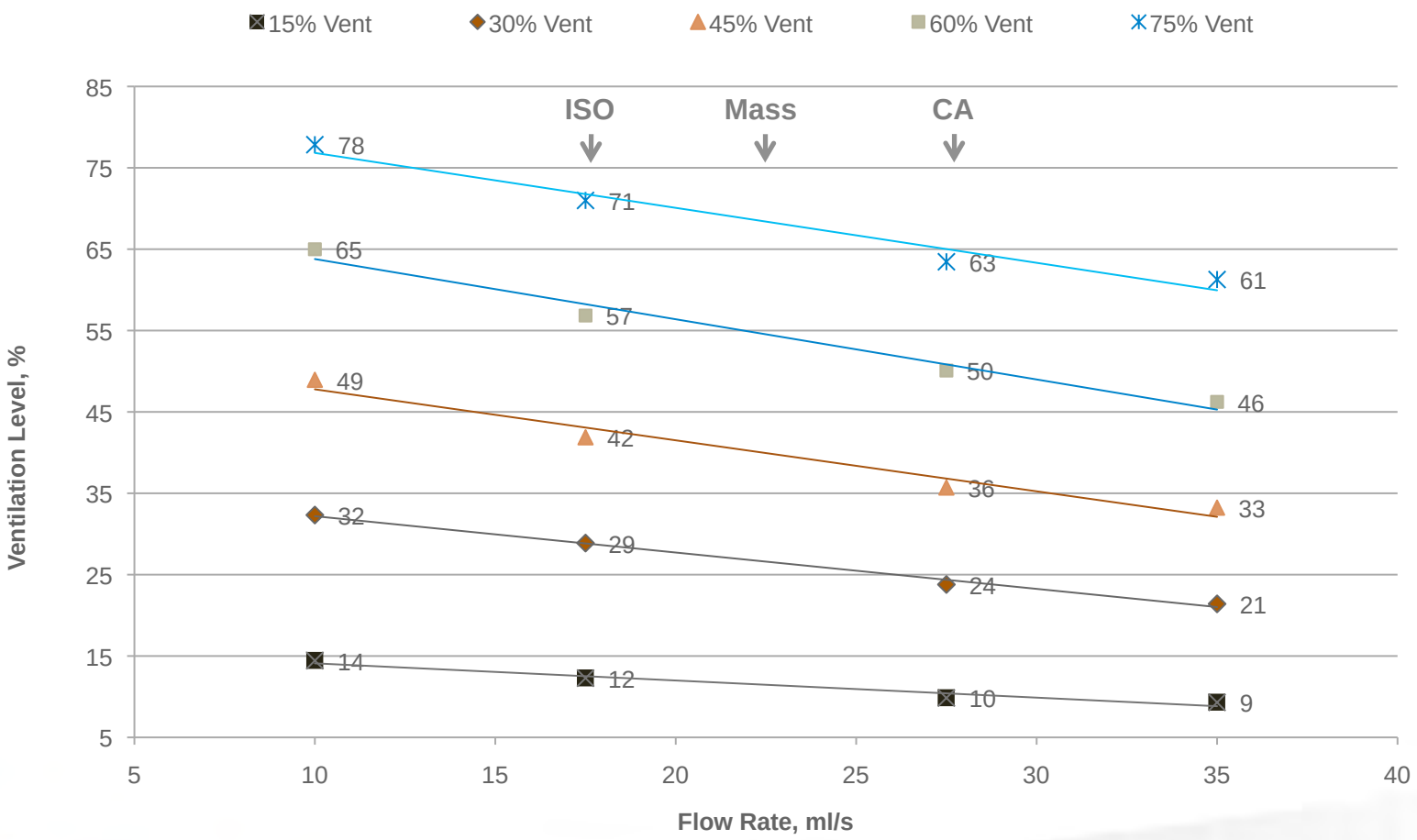
- Objective: To evaluate the influence of flow rate on the ventilation level.
- Conditions: Compare various flow rates.
- Samples: Cigarettes with a range of ventilations (0, 15, 30, 45, 60, & 75%).

- Does the ventilation level change with air flow?
  - If one has 45% ventilation level at 35 ml puff (ISO), what level would be observed with a 55 ml puff?

Pressure drop comparison



Ventilation comparison



Precision comparison - r & R for ranges

	Cigarette Pressure Drop Repeatability (r)	Cigarette Pressure Drop Reproducibility (R)	Cigarette Ventilation Repeatability (r)	Cigarette Ventilation Reproducibility (R)
CORESTA Method No. 4	3 mm WG	6 mm WG	-	-
CORESTA Method No. 6	1.86 – 4.33 mm WG	3.99 – 8.33 mm WG	0.86 – 1.91 %	1.88 - 2.89 %
CORESTA Method No. 41	2.3 mm WG	5.8 mm WG	-	-
CES 508 Instrument	**1.4 mm WG**	**-**	**1.7 %**	**-**

Summary

- A new pressure drop and ventilation instrument with adjustable flow rates has been designed and built.
- Various new design features were utilized to allow improved accuracy and precision.
  - Redesigned air paths ways to allows higher air flow rates
  - Microprocessors allowing real time measurement of air flow rates
  - Separated zones to reduce influence of electronics heating on air measurements
  - Compensation for room temperature, relative humidity, and barometric pressure
- Experimental results show good precision.
- A demonstration experiment shows that a filter’s pressure drop and ventilation are significantly influenced by the air flow rates.

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EXTRA SLIDES

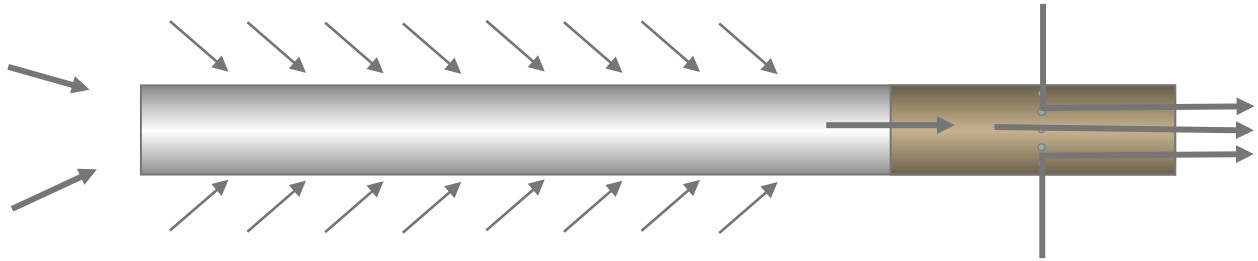
Contact Information

Custom Electronic Systems, Inc. (CES)
455 Forum Parkway
Rural Hall, North Carolina 27045
336-969-2411
http://www.draftrange.com/
ces@draftrange.com

Precision comparison

- CORESTA Guide No. 4
  - A User Guideline for Measurement of Pressure Drop of Cigarettes and Cigarette Filter Rods
- CORESTA Recommended Method No. 6
  - Determination of Ventilation – Definitions and Measurement Principles
- CORESTA Recommended Method No. 41
  - Determination of the Draw resistance of Cigarettes and Filter Rods

Ventilation types



Tobacco column ventilation

Filter ventilation

References

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- “The Effect of Filter Ventilation on the Yield and Composition of Mainstream and Side Stream Smokes”, Beitr. Tabakforsch. Int., 10:81-90, 1980, C. L. Browne, et al.
- “Parameters Affecting the Selective Filtration of Certain Tobacco Smoke Components”, Beitr. Tabakforsch. Int., 8:145-9, 1975, by G. P. Morie, et al.
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- “The influence of water on the selective filtration of phenol in upstream versus downstream segments”, Watts & Wilson, TSRC 2008.
- “Smoke composition changes resulting from filter ventilation”, S. A. Wilson, TSRC 2001.