



OPERATING INSTRUCTIONS
DigiCal™ Primary Calibrator
Catalog No. 655101

INSTRUCTION MANUAL

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Section 1

Analysis of Air Flow Calibration

a. Physics of Measurements:

At room temperature, all gases obey - to a very close approximation - the ideal gas equation $PV = nRT$, where P is the pressure in newtons per square meter, V is the volume in cubic meters, n is the number of moles of gas, R is the empirically determined gas constant with the approximate value 8.31 joules/mole degrees Kelvin and T is the temperature in degrees Kelvin.

The method of measuring flow rates in the DigiCal Calibrator is the technique known as the soap film bubble test. A frictionless soap film is suspended perpendicular to the air flow up a small bore tube. This film forms a complete seal across the tube. The effect causes the soap film to move along the tube at exactly the same rate as the air flow. Knowing a measured distance and tube bore size, a volume can be calculated. Thus, a flow rate can be determined by the movement of soap film across a fixed volume per unit of time. This technique is classified as a Primary Standard.¹

By comparing the four variables of the Ideal Gas Law against this detection technique, the validity of measurement can be accessed. The volume (v) is known and fixed therefore cannot change or be considered variable. The mass (m) of the gas being measured is not changed in this technique as the soap film is simply suspended across the tube cross section and moves with the gas flow rate. Mass is not affected. This leaves pressure and temperature. These are expressed by Boyle's Law $P_1V_1 = P_2V_2$ and Charles Law $V_2 / V_1 = T_2 / T_1$. No pressure changes from the ambient during a test as the soap film is practically frictionless. Temperature has no influence in this type of flow measurement when all elements are at an ambient. This includes the Calibrating device, the flow of gas and room temperature. These conditions are the general circumstances in which tests are performed.

Conclusion: The detection method of measuring flow rates of gases over a fixed volume per given unit of time is for all practical purposes independent of all variables in the Ideal Gas Law. Thus, the DigiCal Calibrator serves as a primary standard calibration method.

¹Lippman, Morton, "The Industrial Environment - its Evaluation and Control," [U.S. Department of Health, Education and Welfare], NIOSH, 1973, Ch 11, 101 pp

b. Accuracy of Gaseous Flow Measurements

To properly evaluate the accuracy of flowing gases, two parameters must be considered. First, the steadiness of the flow rate must be known. Practically every type of pump creates some pulsing of the flowing gases. Second, the rate of flow can drift up and down over some range. Current battery powered personal air sampling pumps use various techniques to dampen pulsing and special circuitry to monitor pump speed, thereby, attempting to generate constant and steady flows.

The DigiCal Calibrator is an automation of the "classic" technique of using a soap film seal to measure flow over a predetermined volume in a known time. A microprocessor, operating at 6 megahertz per second, detects the passing of the soap film seal over the established flow tube volume and automatically calculates the rate of flow. The typical apparatus, 1,000 ml buret using a stopwatch, can be significantly reduced in size since the microprocessor can detect and measure the speed at 80 microsecond intervals. Compare this speed to a technician's response time. With good precision on a stopwatch, he or she could be repeatable within 50,000 microsecond (0.05 seconds), 625 times slower than the microprocessor.

Consider this analysis: 1,000 cc buret NIST traceable; 0.01 second stopwatch crystal controlled with clock accurate to ± 15 sec per month; 1,000 cc/min steady flow source (constant flow ± 1 cc/min).

Example: Measure the flow rate using 1,000 cc buret by a skilled technician. All devices are at a constant room temperature.

Test	Time	Actual Flow Rate
1	60.06 sec	999.0 cc/min
2	60.00	1000
3	59.94	1001

Note: At 1,000 cc/min of flow ± 0.06 is equal to 1 cc/min change or ± 0.1 accuracy. Repeatability is strictly a function of the technicians skill.

Mathematically, it would seem 0.1% accuracy could be obtained using this large volume and a skilled technician with a 1,000 cc/min. steady source. Of course, if the volume is smaller than 1,000 cc or the flow is faster, the percent of accuracy is further reduced by this manual method.

To summarize, the accuracy of measuring air flow relies on quality measurement tools such as NIST traceable buret and crystal control stopwatch. A constant air flow source and a reliable method of detection are the final requirements to achieve repeatable and accurate flow readings.

Section 2

Principle of Operation and Features

a. Detection Principle:

The DigiCal Calibrator utilizes the principle of measuring the flow rate of gases over a fixed volume per unit of time. A Quartz controlled timer is the timing device and the fixed volume is located in the flow cell center tube. A microprocessor measures the time for a frictionless soap film to travel from the first sensor to the second sensor (infrared which detects the passage up the tube) and then calculates the volume per unit of time. The results are displayed in flow rate, cc/min. on a four digit liquid crystal display. The decimal point floats to present the data in the proper range. The timer is capable of detecting a soap film at 80 microsecond intervals. This speed allows under steady flow conditions an accuracy of +/- 0.5% of any display. The unique flow cell can create a soap film over a range of 1 cc/min. to 6,000 cc/min. The flow cell is spillproof when properly filled.

b. Understanding the Display Results

A unique feature of the microcomputer software program is data display. On initiation, the DigiCal display will present 0000's with no decimal point indicated. A series of --- are displayed while a test is in progress. During sequential tests, the previous reading is added to the current test, divided in half, and displayed. If the previous reading and current reading are different by more than $\pm 5\%$ a series of EEEE's will flash four times on the display and then display the actual last test result. The next flow readings will start this averaging technique over again. If individual readings are desired without averaging, the "ON" button may be pushed to reset the unit to "0000" following each test. The flashing numbers on the display after a test are for three seconds duration. The purpose is to allow sufficient time for the soap to return to the bottom reservoir.

c. Battery saver

Another feature of the DigiCal Calibrator is the battery saver "automatic shut down". If a test is not conducted within approximately 7 minutes from turn on, the Calibrator will turn itself off. Continuous use of the batteries is rated at 8 hours. The unit may also be operated directly from the A/C charger when batteries are low. All units should be given an initial 16 hour charge prior to use. A low battery light will indicate when it is time to recharge the battery. If stored for a period of 30 days or more, unit will require a 16 hour charge prior to operation.

Section 3

Start Up Procedure

- A. Read the previous section of Principle of Operation if unfamiliar with device.
- B. Soap volume is not critical, therefore a measured amount is not necessary. The proper amount is that which is sufficient to create a bubble. Simply pour a small amount of soap through the bottom nipple to thoroughly cover the bottom of the flow cell and attach air source to nipple (bottom nipple for pressure, top nipple for vacuum). Excessive amount of soap may cause a continuous stream of bubbles to go up the center tube at high flows.



- C. Wet flow cell by connecting a pump flowing at 1000 to 2000 cc/min. Initiate soap film up center tube by rapidly pressing button down and releasing. Repeat this procedure until bubble doesn't break. The tube is now wet and tests at any range may be conducted. One minute warm up time is all that is required of the DigiCal.



Section 4

Calibration Of Air Flow Sources With The DigiCal Calibrator

The instructions relate to industrial hygiene air sampling. It, basically, applies to any gases flow rate measurements.

1. Start the pump and allow approximately 5 minutes to stabilize. Perform this step before connecting to flow cell as air flow dries center tube if bubbles are not initiated at intervals.
2. Connect sampling medium to pump by obtaining proper hose adapters for connecting tubing to flow cell. The flow cell hose connectors will accept two common sizes of vinyl tubing (1/4" and 5/16"). A "Luer" fitting is incorporated in the upper hose connector. The upper port is for vacuum and the bottom for pressure. When the upper port is connected to vacuum, the lower port must be open to the atmosphere. Conversely, when the lower port is connected to pressure, the upper port must be open to free air. Never make bubble test with bottom hose connected in series (in line with sampling filter).
3. Wet the flow cell as described in Section 3.
4. Begin Calibration:
Depress plunger into cell and quickly release.
Different flow rate can require quicker or slower release of the button.
5. Carefully observe the bubble passing through the sensor zone. Only a single straight bubble, perpendicular to the tube wall, is necessary for an accurate test. If several bubbles go up to the tube at once it will not effect the test data because the first sensor will not reset until the final sensor has been tripped. A good technique is to watch the bubble pass up the tube to ensure a good test has been conducted.
6. Observe the display. A number will be displayed. The decimal point will be appropriately placed. Read section 2-b on features concerning data display.

7. After a 3 second delay from the time the final sensor is tripped another test can be performed.
8. Repeat Steps 5 through 8 for minimum of 3 tests.

Note:

If difficulty is encountered in making a clean single soap film rise up the center tube:

- a. Check level of soap in flow cell (Section 3-C).
- b. If soap is cloudy (not clear), change the soap solution and clean flow cell.

Section 5

Maintenance Of Calibrator

General Information:

To clean the flow cell, simply remove the three screws holding the flow cell to the bottom of the case. Remove the flow cell and gently flush with tap water. To prevent scratching the acrylic flow cell, wipe "only" with a soft cloth. Do not allow center tube, where sensors detect soap film to be scratched or get dirty. NEVER clean with ACETONE. Use only soap and warm water. When cleaning prior to storage, allow flow cell to air dry. Shake any access water from cell prior to reattaching to base of DigiCal Calibrator.

If stubborn residue persists, remove the bottom plate. Squirt a few drops of soap into slot between base and flow cell to ease removal. Gently insert a coin or flat screw driver into the ridge between the bottom plate and chamber using leverage around the circumference of the cell until the bottom plate is removed. Upon realigning, note scribe mark near one of the screw inserts on bottom plate and align this mark with scribe mark on flow cell near air hose inlet. Again, wet O-ring with soap prior to installation.

To reassemble, realign flow cell in case with hose nipples pointing to back of case and reinstall the three bottom screws.

Section 6

Verification Of Calibration

The calibrator is factory calibrated using a standard traceable to National Institute of Science and Technology (N.I.S.T.). Attempts to verify calibrator against a glass one liter buret should be conducted at 1000 cc/min. for maximum accuracy. The calibrator is linear throughout the entire range.

Section 7

Power For The DigiCal Calibrator

1. The battery supply utilizes 4 Nicad Sub C batteries. The unit will operate up to 8 hours on a fully charged battery. The unit may also be operated directly from the AC charger when batteries are low.
2. Low battery light will indicate the power supply is too low for accurate results.
3. Charge battery pack for 16 hours minimum using the standard charger supplied with the unit.
4. A special power saving feature is the Automatic Shut Off. After 7 minutes of non-use, the DigiCal Calibrator will shut off automatically.

Section 8

Notes/Precautions

1. Avoid the use of chemical solvents on flow cell, calibrator case and faceplate. Generally, soap and water will remove any dirt. Use of chemicals can result in a damaged cell requiring replacement and calibration.
2. Never pressurize the flow cell at any time with more than 25 inches of water pressure. Overpressurizing can cause leaks in the cell resulting in erroneous flow readings.
3. CAUTION: Do not leave A/C adapter plugged into calibrator when not in use as this could damage the battery supply.
4. NOTE: Hose fitting covers help to reduce evaporation of soap in the flow cell when not in use.
5. Use only DigiCal Calibrator Soap. It is a precisely concentrated and sterilized solution formulated to provide a clean, frictionless soap film bubble over the wide, dynamic range of the calibrator. The sterile nature of the soap is important in the prevention of residue build-up in the flow cell center tube, which could cause inaccurate readings. Do not use any other soap.

Section 9

Parts List

A/C adapter charger	120V	655112
	230V	655168
Soap solution		600920
Instruction manual		655103
Air inlet caps (Pkg. of two)		655102
Sub C battery pack	4 in line	655169

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