Duct Leakage Testing

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Agenda

- Need for duct leakage testing
- Duct leakage testing standards and regulations
- Performing duct leakage testing

Why Test Ducts for Leakage?

- Conserve energy
  - 10-30% of heated/cooled air lost through ductwork
  - Leaky supply ducts don’t delivery air where needed
  - Leaky return ducts add load

Why Test Ducts for Leakage?

- Indoor Air Quality
  - Leaky returns can pull in air from uncontrolled spaces, causing
    - Humidity problems
    - Contaminants

System Leakage

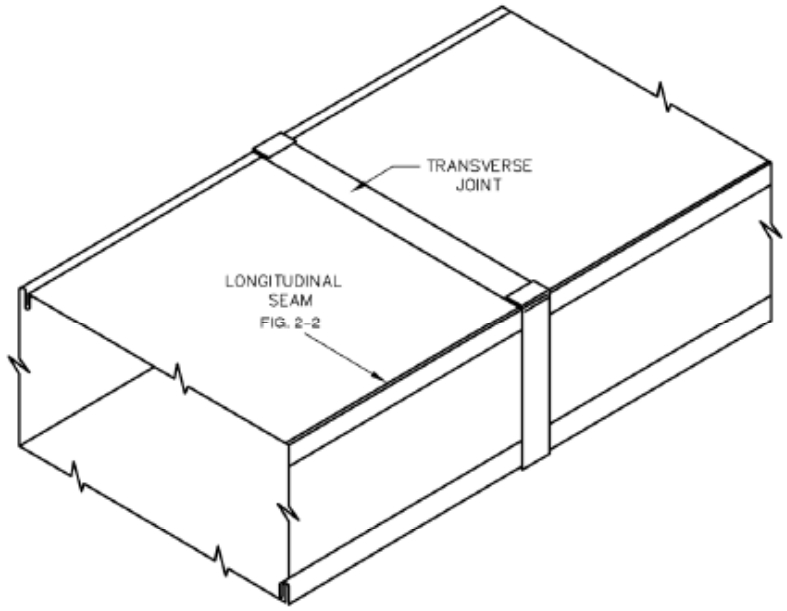
- IAQ, Comfort, Energy issues caused by leakage from HVAC System
- System Leakage = Duct Leakage + Equipment Leakage + Accessory Leakage
- Scope of presentation = Duct leakage
  - Does not include:
    - Leakage through Equipment (See ASHRAE 193)
    - Leakage through Accessories
  - Commercial & industrial systems
    - Similar concepts for residential

Why Test Ducts for Leakage?

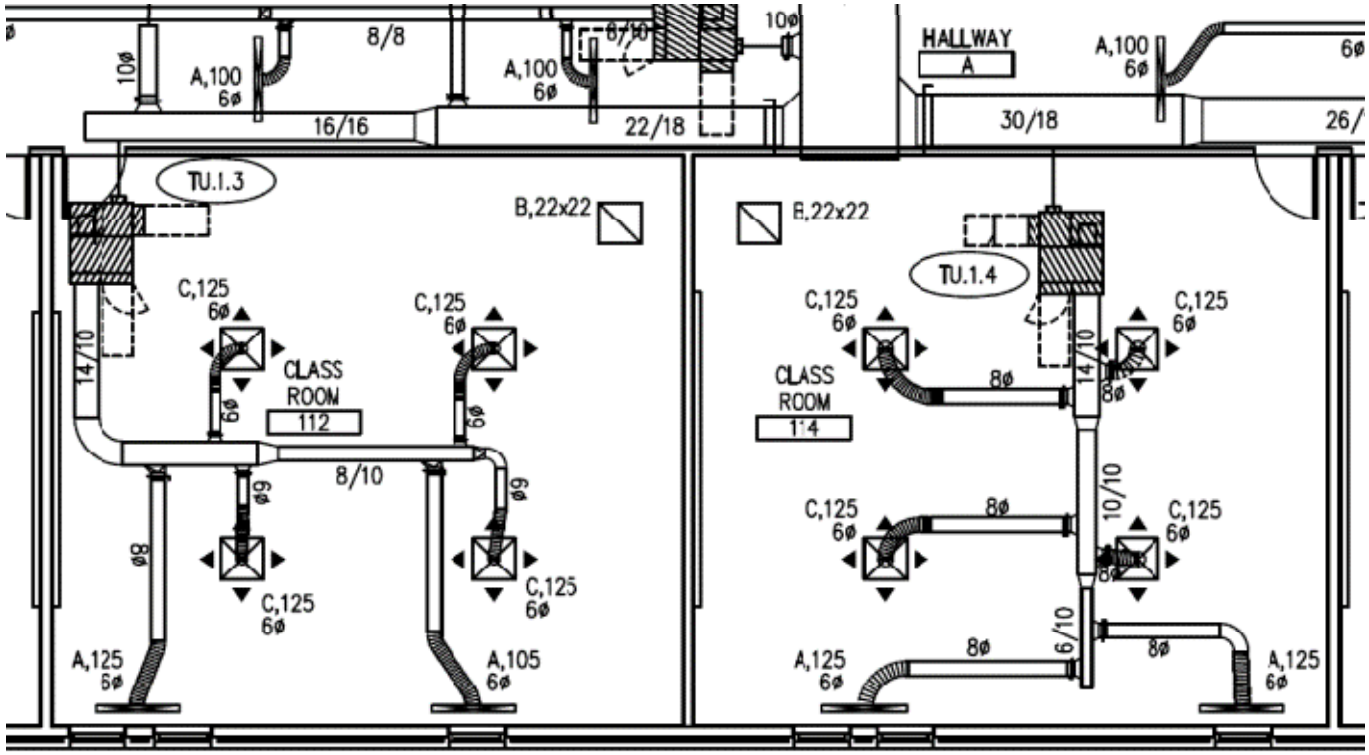
- Requirements
  - US
    - SMACNA HVAC Air Duct Leakage Test manual, First edition, 1985
    - ASHRAE 90.1 (Proposed)
    - Project specifications
    - California Title 24 → residential testing required if ahu/furnace in garage or ducts in non-conditioned space (attic)
  - Europe
    - BS EN 12237:2003 – Circular Ductwork
    - BS EN 1507:2006 – Rectangular Ductwork
    - DW/143 (HVAC—A practical guide to Ductwork leakage testing)
    - Eurovent 2/2 (Air leakage rate in sheet metal air distribution systems)

Where Does Duct Leakage Occur?

- Transverse Joint
  - Duct-to-duct, -branch, -tap, etc.
- Longitudinal Seam
  - Joining of 2 edges in direction of airflow
- Penetration
  - Rod, wire, tubing, etc.
- Sealing not required:
  - Spiral seams
  - Screws & fasteners
  - Damper rods



Where Does Duct Leakage Occur?



- Higher-pressure ductwork
  - ASHRAE 90.1 recommends only testing ductwork rated >3 in H_2O
  - Don't test flex duct

How to Test Duct Leakage (Basic)

- Identify ductwork section to be tested
  - Calculated surface area
- Seal ductwork
- Pressurize ductwork to specified level
- Measure flow required to maintain duct pressure
- Compare to standards

Duct Leakage Measurements

- % of Flow requirements
  - Problem: Disregards size of ductwork & static pressure
  - i.e. 1% of flow on 3900 cfm system = 39 cfm.
    If 1300 ft^2 duct area = 3 cfm leakage / 100 ft^2
    300 ft^2 duct area = 13 cfm leakage / 100 ft^2
- Test pressure requirements
  - Problem: Test pressure higher than duct design
  - i.e. testing system designed for 2 in H_2O operation at 10 in H_2O
- Need to consider
  - Surface area of ductwork
    - Type of ductwork (round, rectangular)
  - Static pressure

US Duct Leakage Testing Requirements - (SMACNA)

Duct Class	½-, 1-, 2-inwg	3-inwg	4-, 6-, 10-inwg
Seal Class	C	B	A
Sealing Applicable	Transverse Joints Only	Transverse Joints and Seams	Joints, Seams and All Wall Penetrations
Leakage Class (C_L) – CFM Leakage per 100 ft^2 @ 1 in H_2O			
Rectangular Metal	24	12	6
Round Metal	12	6	3

$$F=C_L * P^{0.65}$$

- F = Max Leakage (cfm/100 ft^2)
- C_L = Leakage Class (from table above)
- P = Pressure (in H_2O)

Prior to Field Testing

Prior to Field Testing

1) Duct System Designer:

   Include on Design/Contract Drawing:

   - Specify Duct Pressure Classification

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Duct Leakage Equation

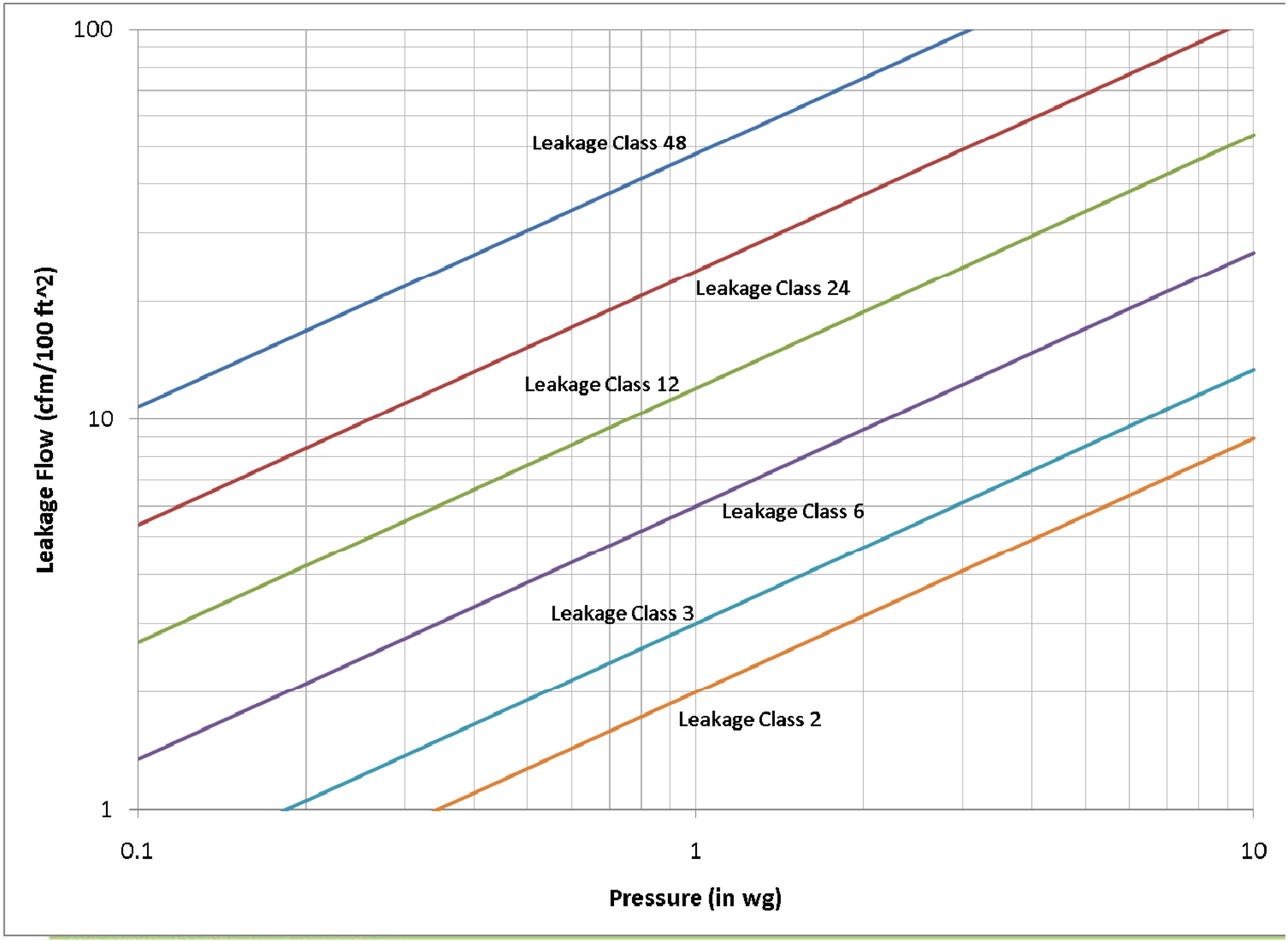
$$F = C_L P^{.65}$$

Where duct

F = Leakage [CFM] / 100 ft^2

C_L = Duct Leakage Classification

P = Duct Static Pressure [“w.g.]



Prior to Field Testing

1) Duct System Designer:

Include on Design/Contract Drawing:

- Test (or not) as installed? Depends on design intent/requirements
- If Test: Specify on Dwgs
  - Portion of ductwork, or whole system?
  - Positive Pressure? Negative?
  - Provide method details

Prior to Field Testing

Quote from *HVAC AIR DUCT LEAKAGE TEST MANUAL* (SMACNA):

"WHERE NO SPECIFIC DUCT PRESSURE CLASS DESIGNATIONS ARE PROVIDED BY THE DESIGNER THE 1" WATER GAGE PRESSURE CLASS IS THE BASIS OF COMPLIANCE…

Prior to Field Testing

… EXCEPT WHEN THE DUCT IS VARIABLE VOLUME: ALL VARIABLE VOLUME DUCT UPSTREAM OF VAV BOXES HAS A 2” W.G. BASIS OF COMPLIANCE WHEN THE DESIGNER DOES NOT GIVE A PRESSURE CLASS.”

– from SMACNA *HVAC AIR DUCT LEAKAGE TEST MANUAL*, 1985

Prior to Field Testing

2) Testing Agency: Prepare paperwork

- Test plan
- Test report form

Prior to Field Testing

3) Testing Agency: Prepare the site

- Plan/Coordinate with construction/installation contractors
- Blanking materials
- Equipment
  - Select according to Test Requirements
  - Consider
    - System Flowrate
    - Leakage Classification
    - Flow Capacity of Test System

Prior to Field Testing

- Equipment Details:
  - Must use instruments that have been calibrated within the past 12 months
  - Calibration certificates traceable to NIST
  - Consider Test System capabilities:
    - Ability to Log data and download with Time/Date stamp vs. using liquid-inclined and U-tube manometers

Prior to Field Testing

- Contingency planning

  (Designer: Put plans in contract drawing/specs)

  – If duct leak test FAILS – then what?

REMEDIATE!

Prior to Field Testing

- REMEDIATION Plan
  - Seal the leaks
  - Wait for seals to cure
  - Re-test
    - Re-test failed section only?
    - Does section failure trigger need to test more sections?

SPECIFY!

Test Procedure

1) Select Duct Section for Testing

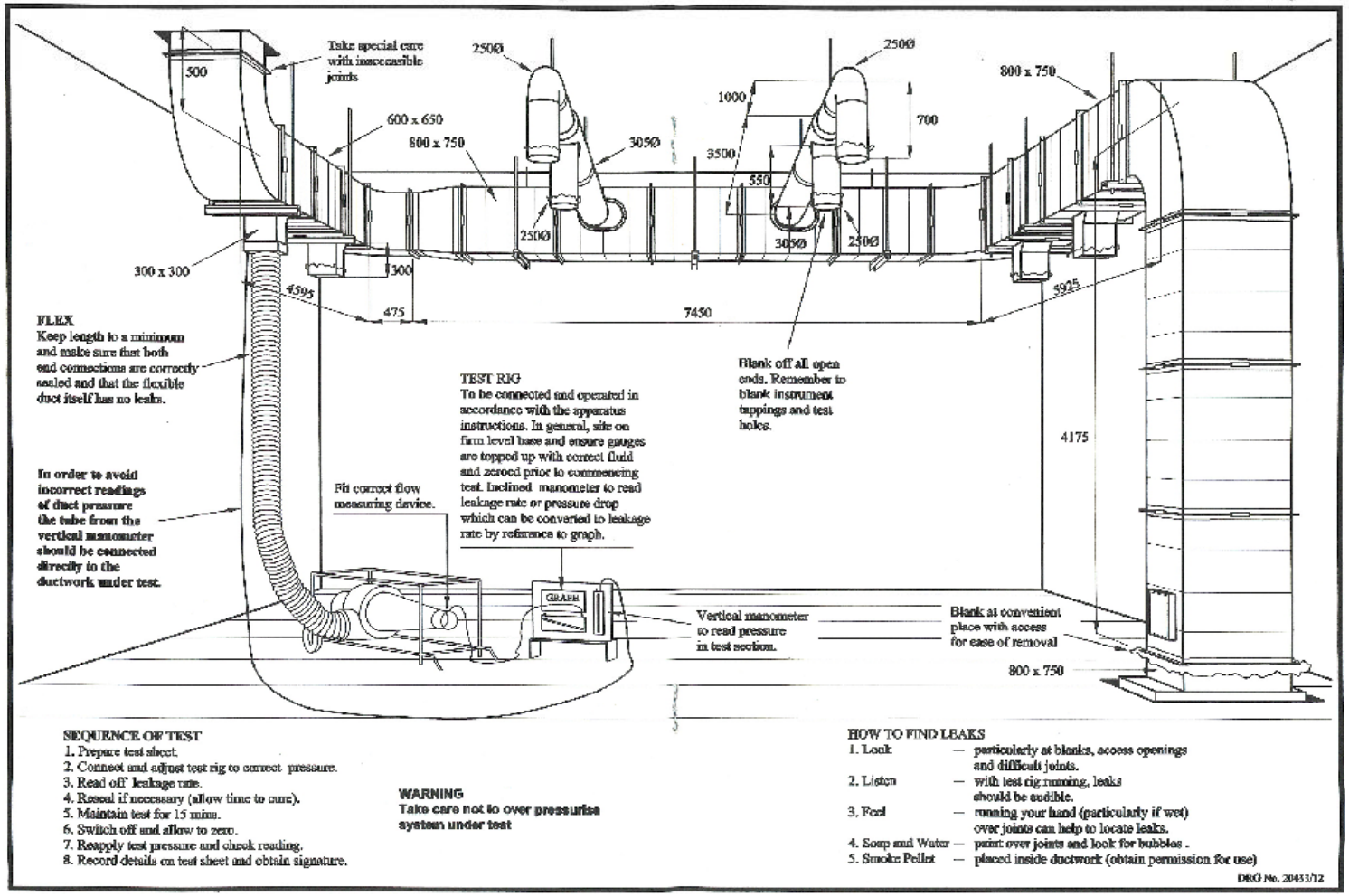
2) Measure and Calculate Duct Surface Area

3) Seal All Openings (except one)

DW/143 Ductwork Leakage Testing *A practical guide*

Fig. 1 Hints on Ductwork Leakage Testing

The dimensions on this ductwork are used in an example on page 7



SEQUENCE OF TEST

1. Prepare test sheet.
2. Connect and adjust test rig to correct pressure.
3. Read off leakage rate.
4. Reseal if necessary (allow time to cure).
5. Maintain test for 15 mins.
6. Switch off and allow to zero.
7. Reapply test pressure and check reading.
8. Record details on test sheet and obtain signature.

WARNING
Take care not to over pressurise system under test

HOW TO FIND LEAKS

1. Look	—	particularly at blanks, access openings and difficult joints.
2. Listen	—	with test rig running, leaks should be audible.
3. Feel	—	running your hand (particularly if wet) over joints can help to locate leaks.
4. Soap and Water	—	paint over joints and look for bubbles .
5. Smoke Pellet	—	placed inside ductwork (obtain permission for use)

DRG No. 20433/12

Test Apparatus

Duct Leakage Test System consists of:

1) Blower with speed control (VFD) to generate range of pressure/flow

2) Flow measuring devices

- Flow Grid/Flow Station (High Flow)
- Orifice Plate (Low Flow)

3) Pressure instruments (manometers)

4) Accessories to attach to duct system

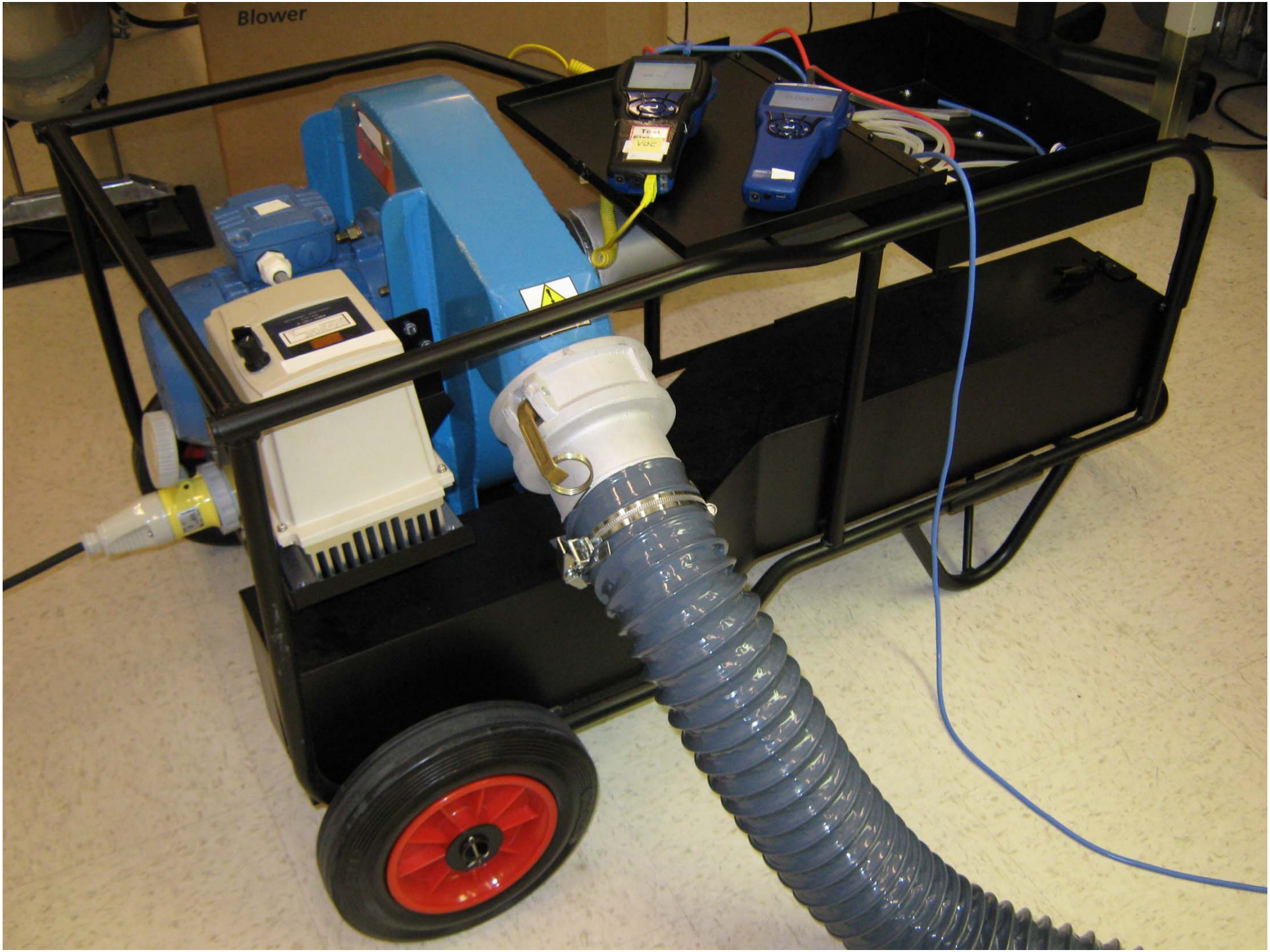
5) Optional item (smoke generator)

Test System: Considerations

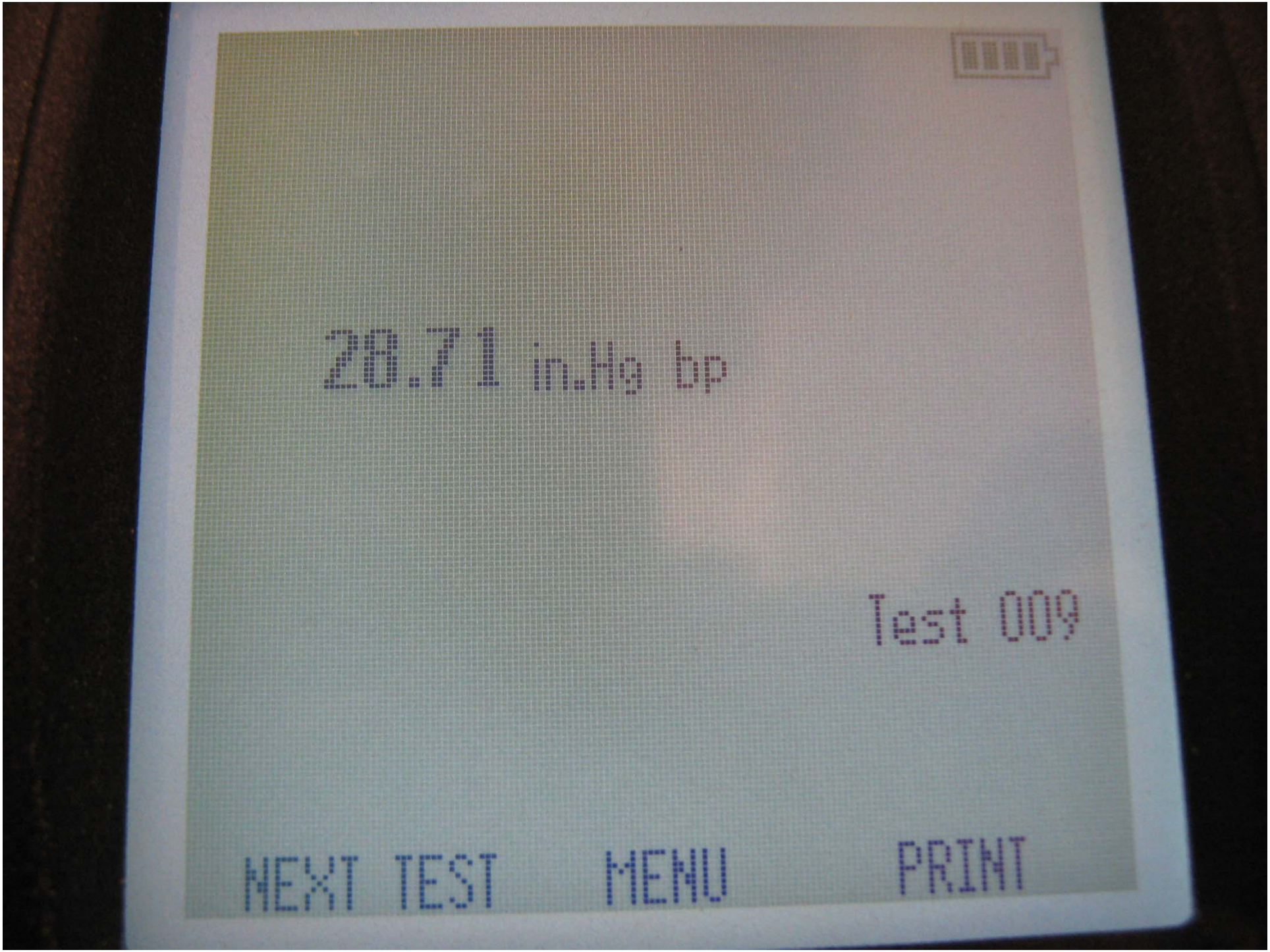
- Maximize: Flow Range
  - Limits duct section size/Leakage Rate
- Maximize: Pressure Range
  - High Pressure Blower to cover duct classes
    - ½” to 10” w.g.
- Maximize: Instrument Measurement Accuracy
  - Flow: 2.5% of reading
  - Pressure: 1% of reading

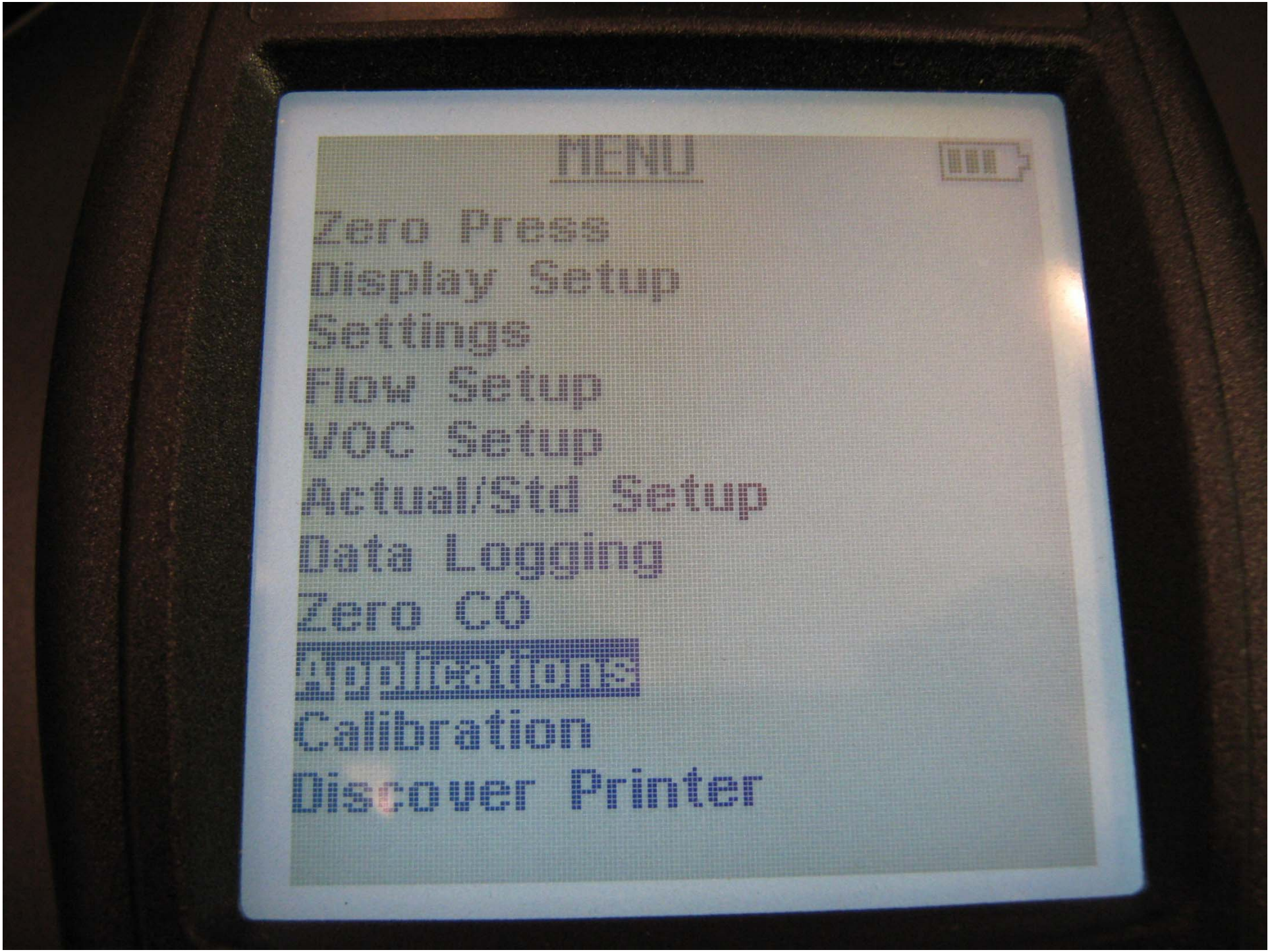
Test System Considerations

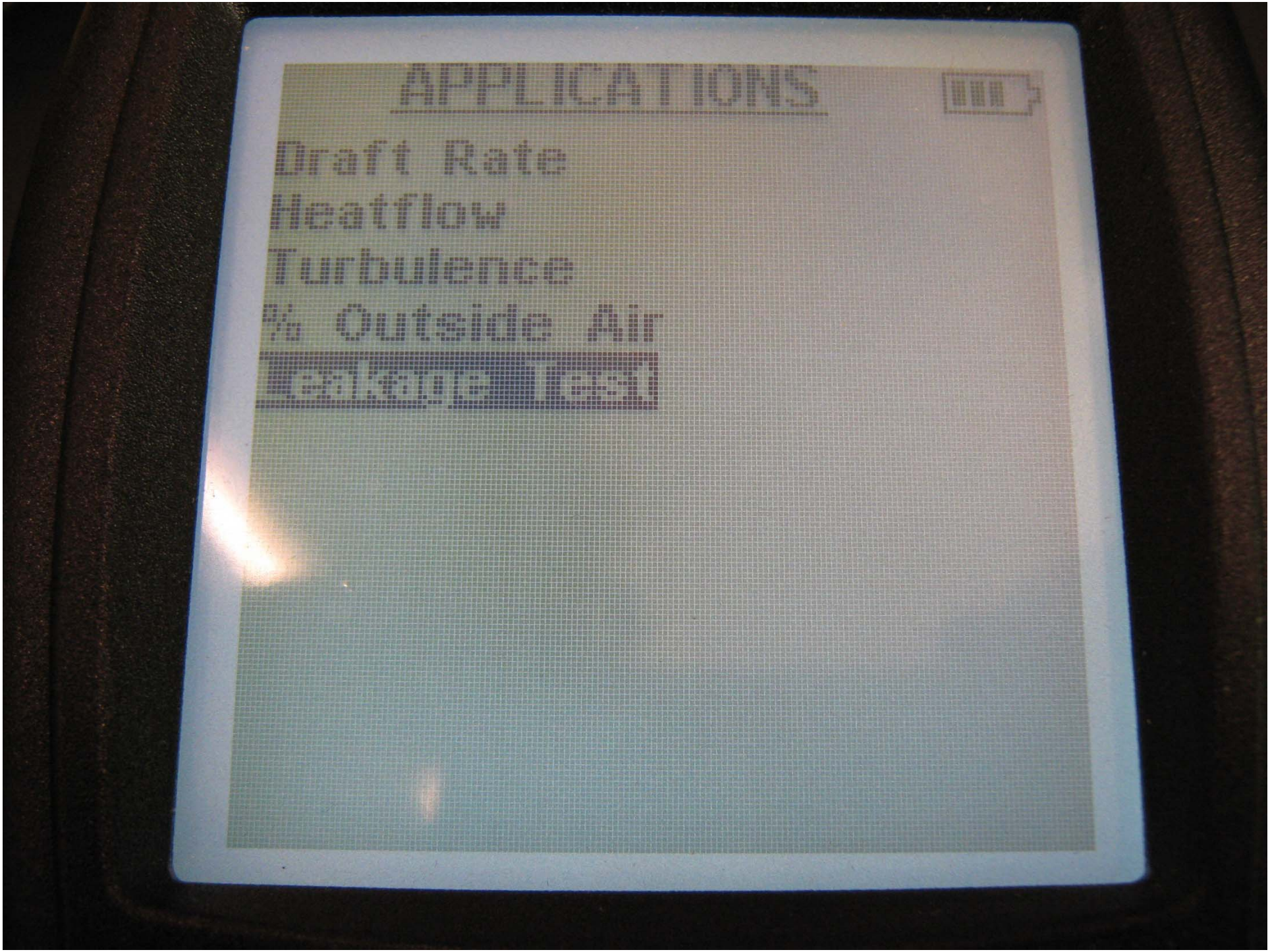
- Instrumentation:
  - Traceable to National Standards (NIST)
  - Logging capability – SIMPLIFY!
    - Time/Date Stamp on each data set
    - Calculates Flows
    - Calculates Leakage rate based on duct ft^2 input
    - Indicates PASS/FAIL status according to selectable defined leakage classifications
    - Report generation and validation

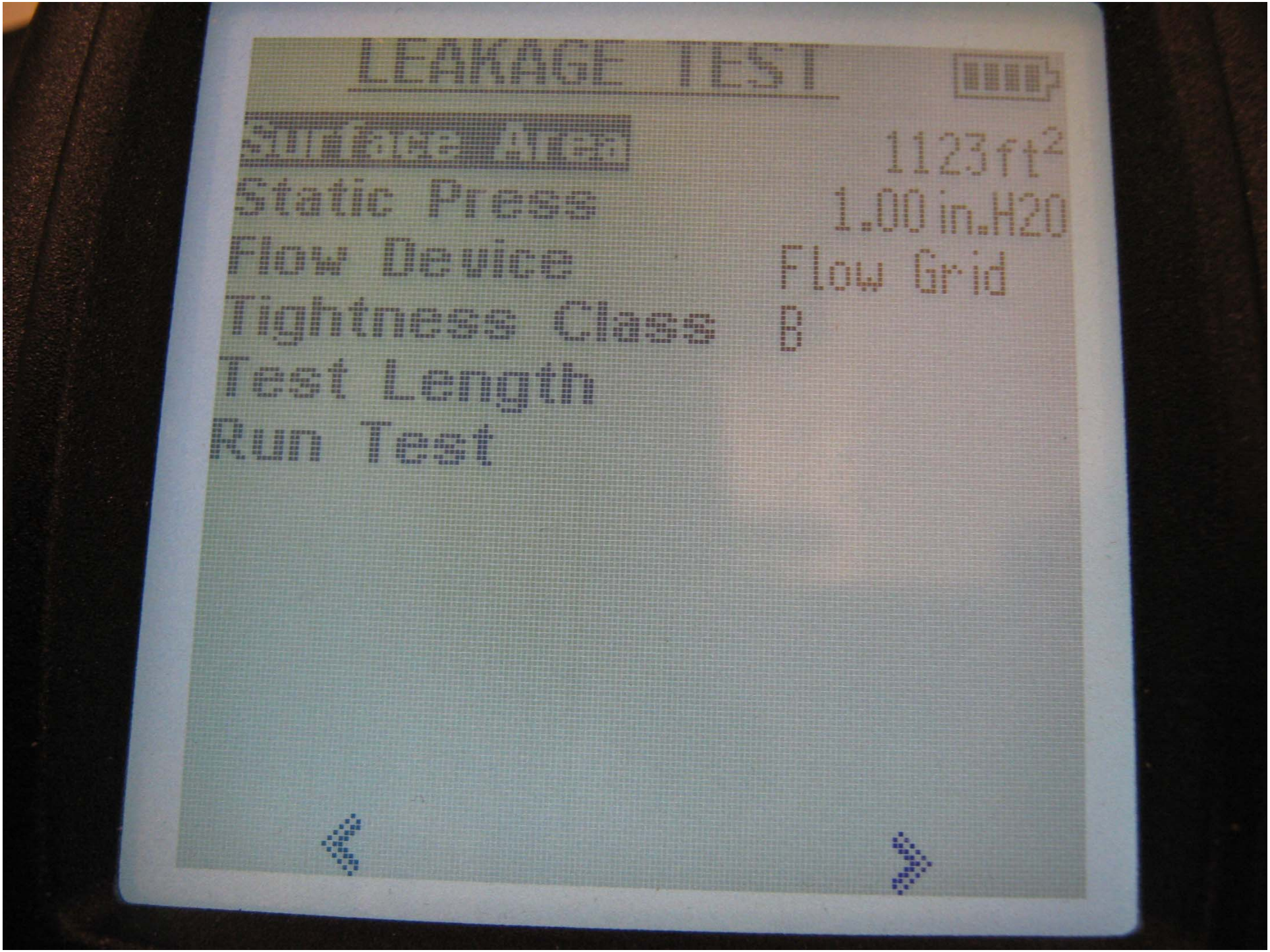

Blower

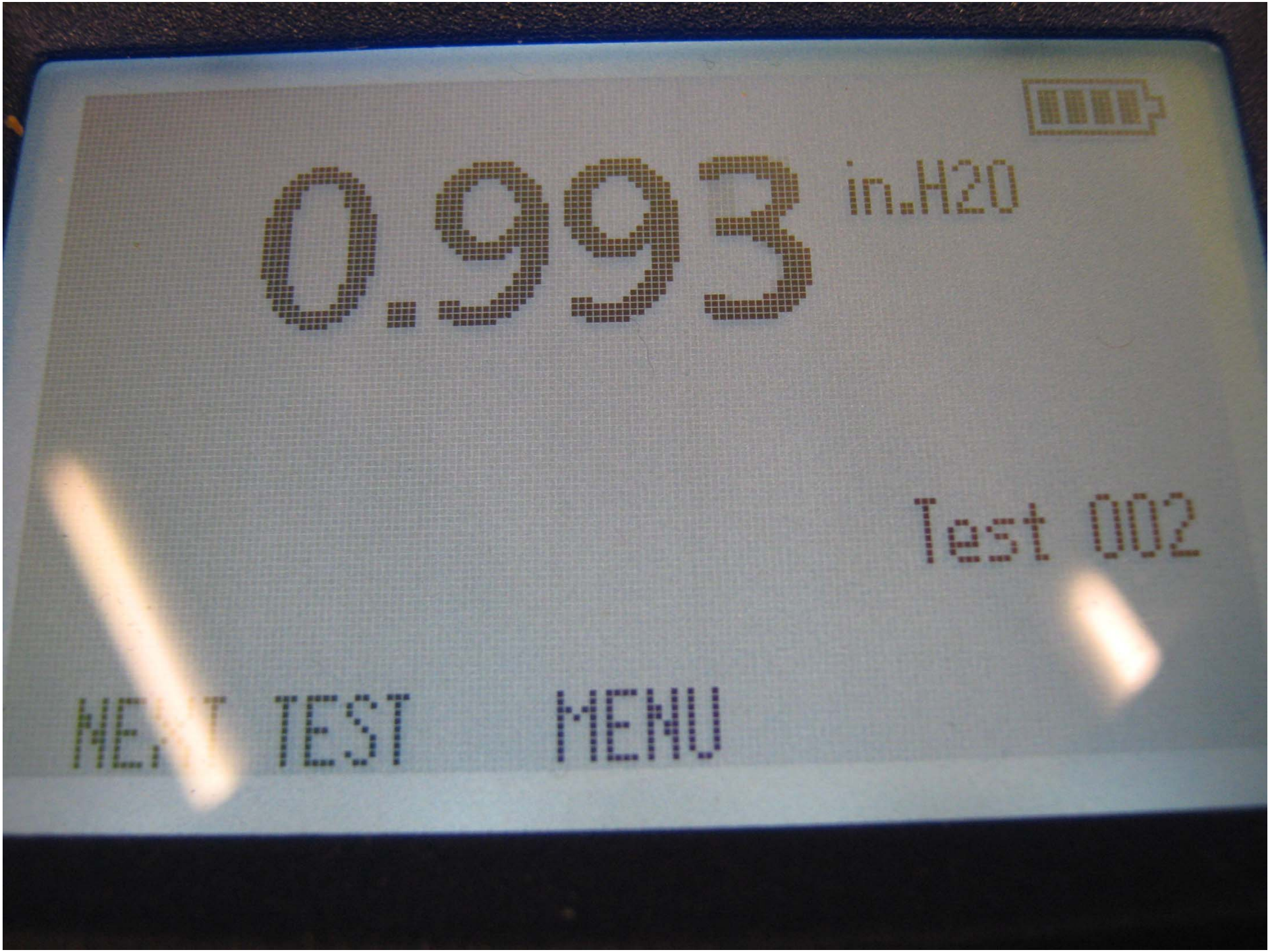

28.67 in.Hg bp
Test 009
NEXT TEST
MENU
PRINT
ESC
Test
Fixture
-0.000 in.H20
Test 002
NEXT TEST
MENU
ESC

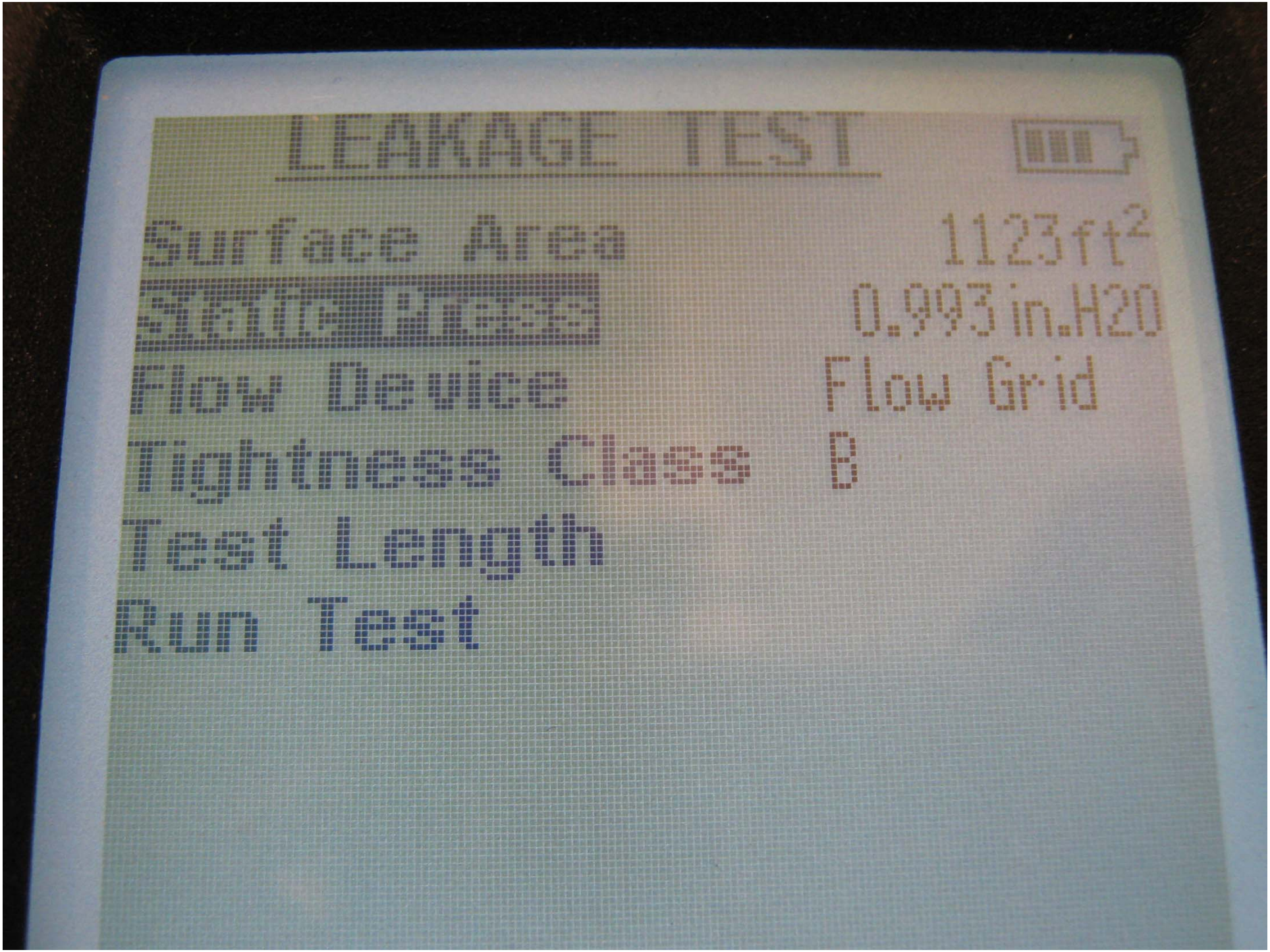

20.71 in.Hg bp
Test 009
NEXT TEST
MENU
PRINT

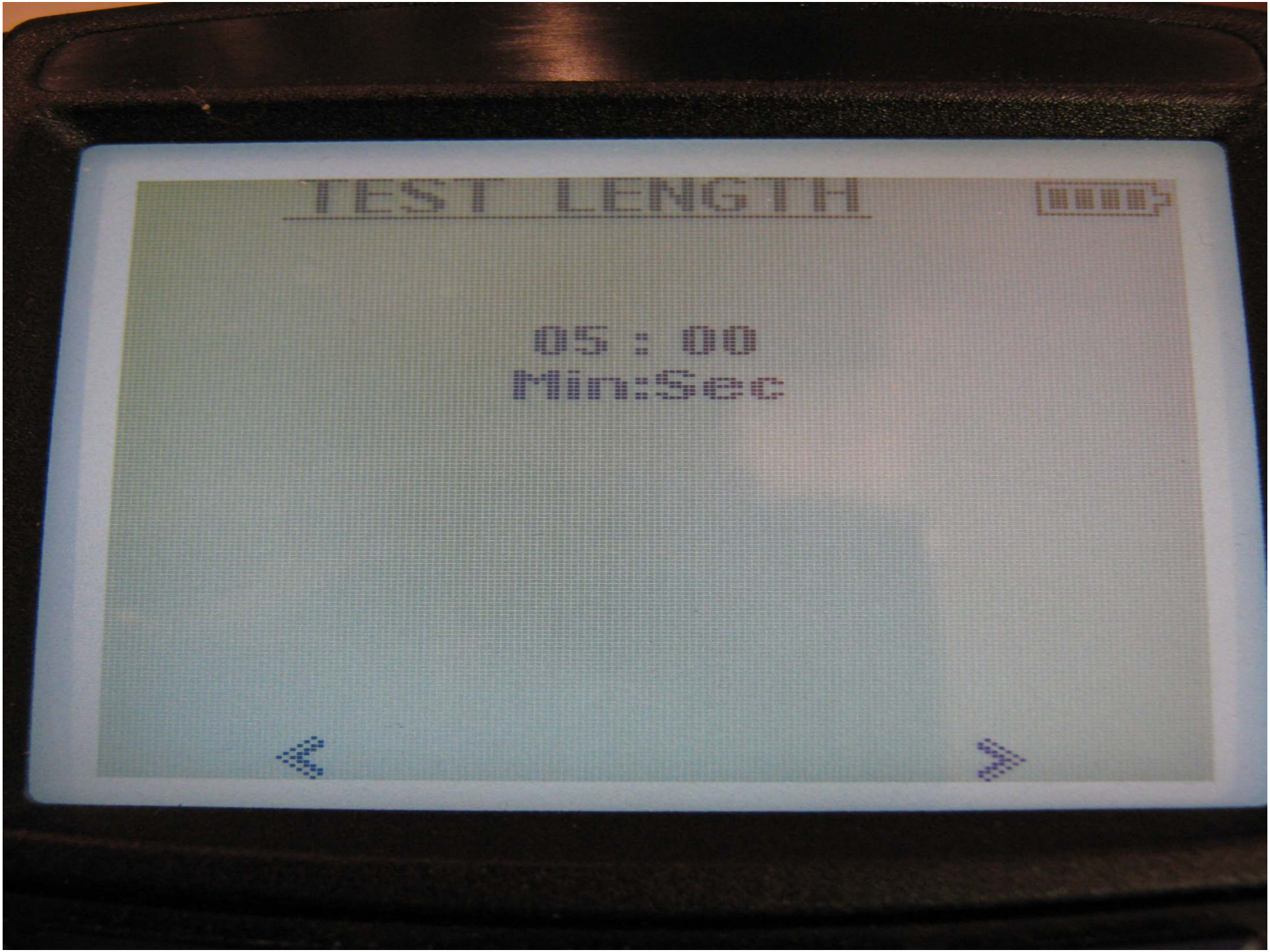

MENU
Zero Press
Display Setup
Settings
Flow Setup
VOC Setup
Actual/Std Setup
Data Logging
Zero CO
Options
Calibration
Discover Printer

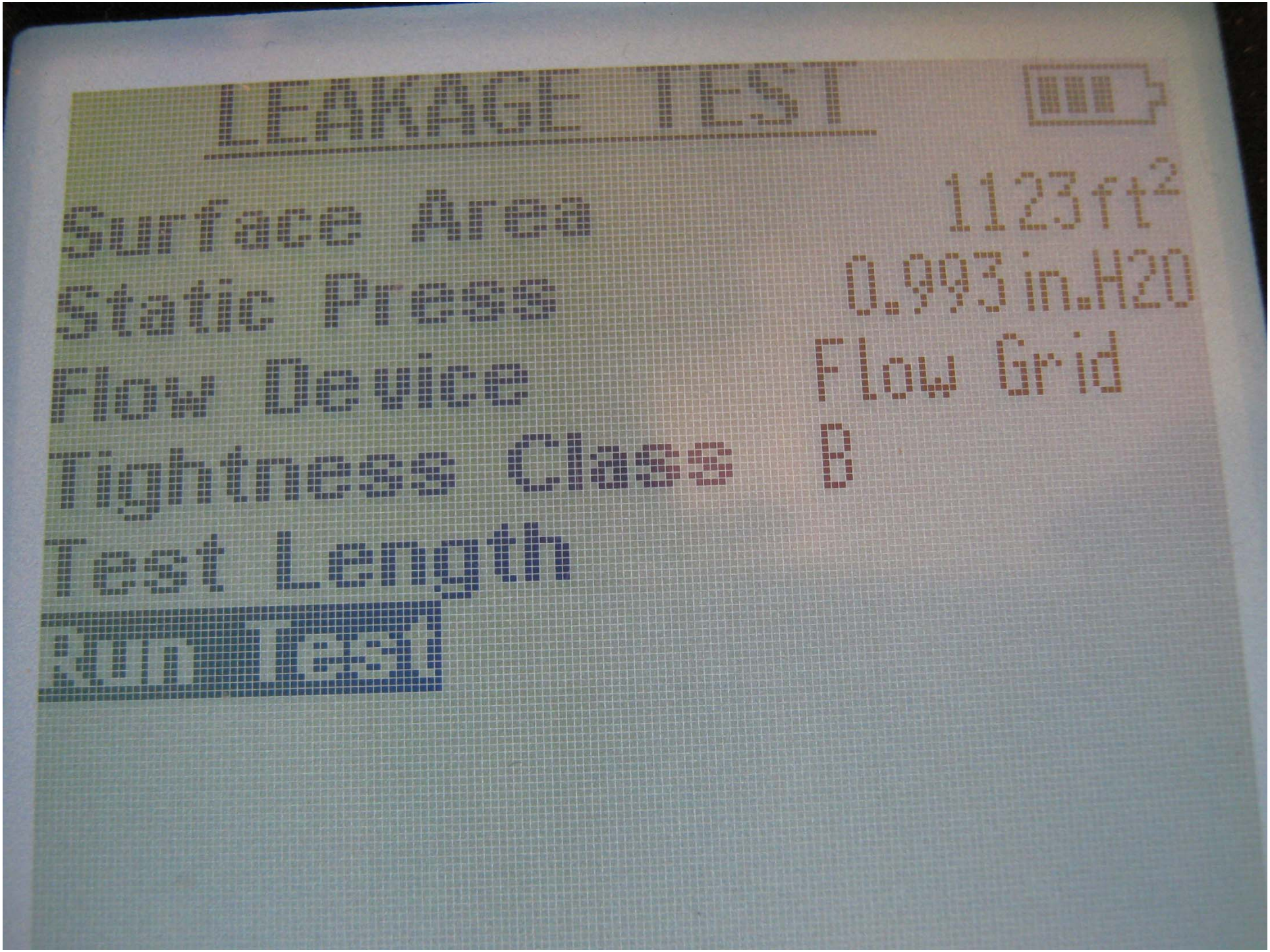

APPLICATIONS
Draft Rate
Heatflow
Turbulence
% Outside Air
Select Test

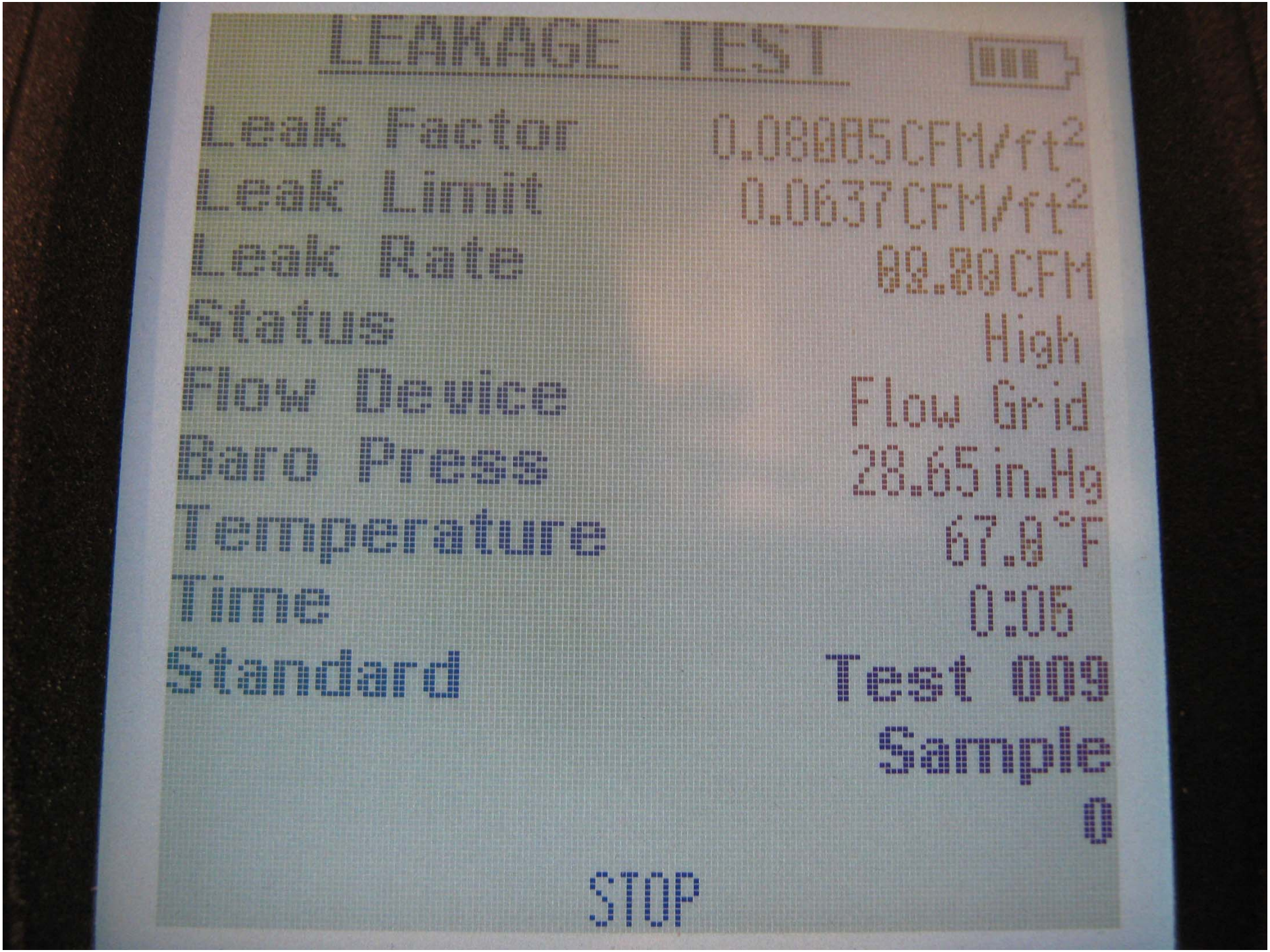

LEAKAGE TEST
Surface Area
1123ft2
Static Press
1.00 in.H20
Flow Device
Flow Grid
Tightness Class
B
Test Length
Run Test

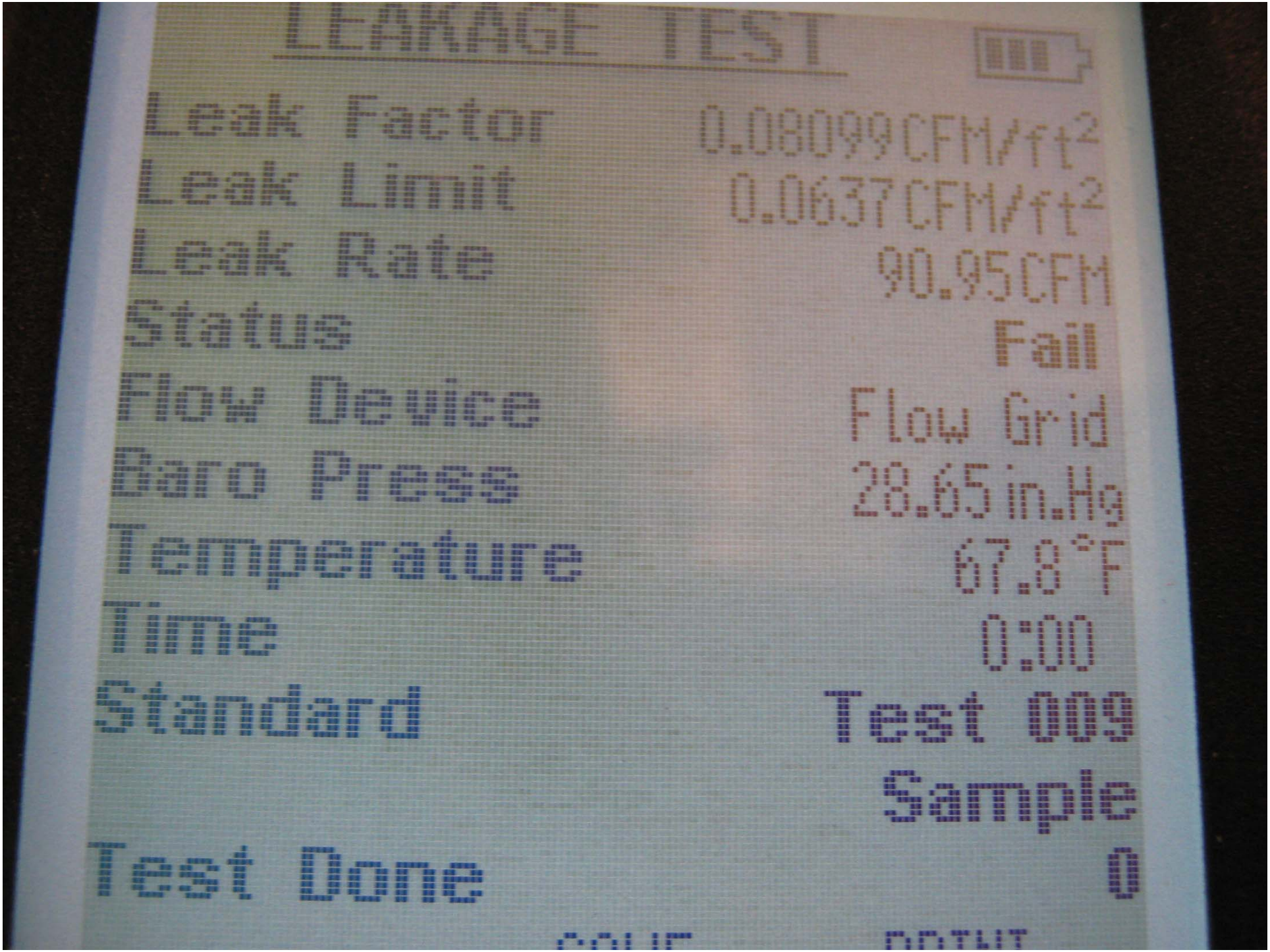

0.993
in.H20
Test 002
NEXT TEST
MENU

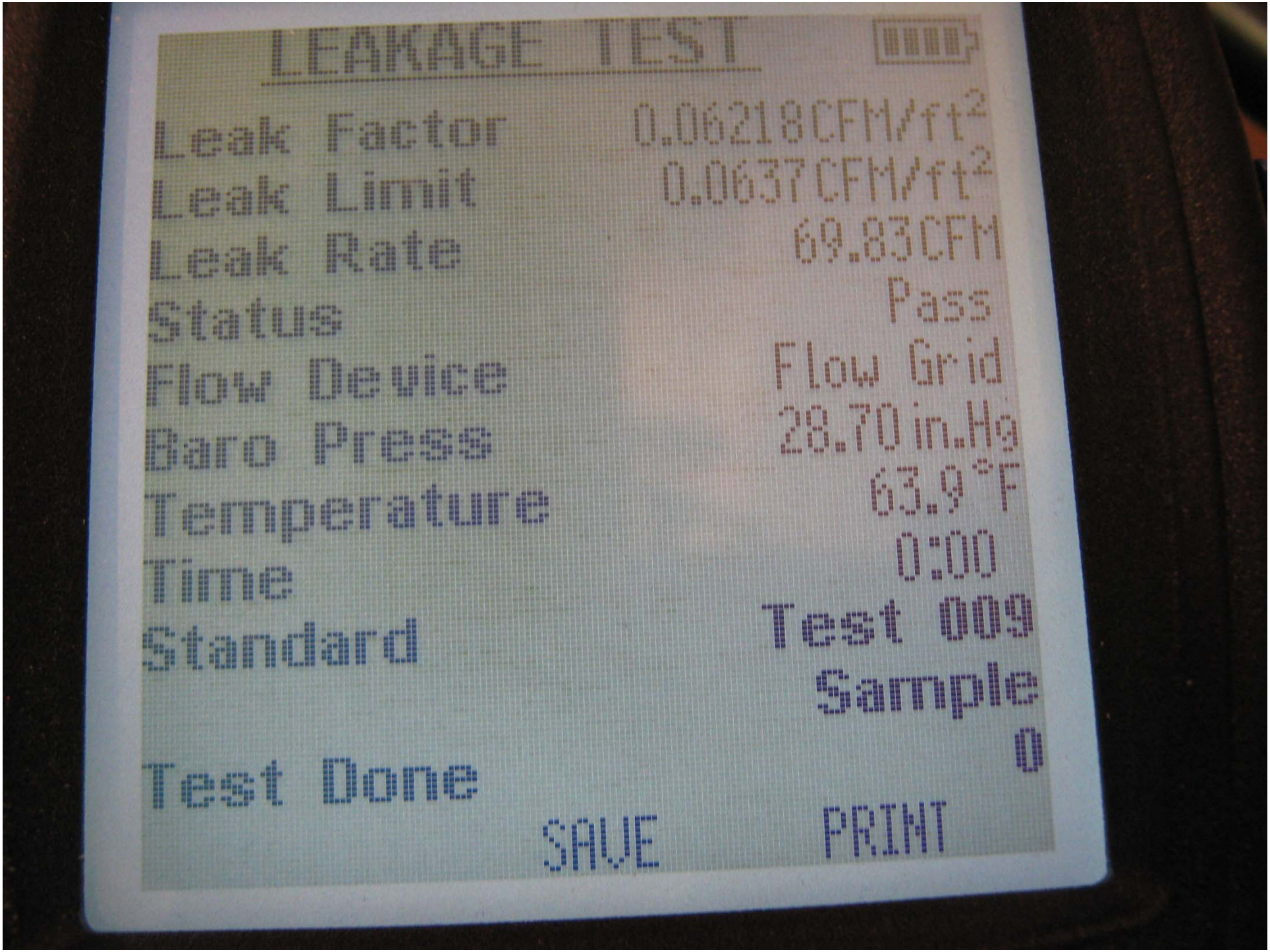

LEAKAGE TEST
Surface Area
1123ft²
Static Press
0.993 in.H20
Flow Device
Flow Grid
Tightness Class
B
Test Length
Run Test


TEST LENGTH
05 : 00
Min:Sec


LEAKAGE TEST
Surface Area
113ft²
Static Press
0.93inH20
Flow Device
Flow Grid
Tightness Class
B
Test Length
Run Test


LEAKAGE TEST
Leak Factor 0.0805CFM/ft²
Leak Limit 0.0637CFM/ft²
Leak Rate 00.00CFM
Status High
Flow Device Flow Grid
Baro Press 28.65 in.Hg
Temperature 67.0°F
Time 0:06
Standard Test 009
Sample 0
STOP


LEAKAGE TEST
Leak Factor 0.08099CFM/ft²
Leak Limit 0.0637CFM/ft²
Leak Rate 90.95CFM
Status Fail
Flow Device Flow Grid
Baro Press 28.65 in.Hg
Temperature 67.8°F
Time 0:00
Standard Test 009
Sample
0
Test Done


LEAKAGE TEST
Leak Factor 0.0621 8CFM/ft²
Leak Limit 0.0637CFM/ft²
Leak Rate 69.83CFM
Status Pass
Flow Device Flow Grid
Baro Press 28.70 in.Hg
Temperature 63.9°F
Time 0:00
Standard Test 009
Sample 0
Test Done
SAVE
PRINT

Summary

- Leaky ductwork is costly
- There are Standards and Test Procedures
- Designer: Be Specific with specs and instructions
- Choose the right Test Equipment

Contacts

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Appendix

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European Duct Leakage Requirements - Round Ducts

Duct Pressure Class	Static Pressure Limit		Maximum Air Velocity m/s	Air leakage limts $l/s/m^2$
	Positive Pa	Negative Pa		
Low pressure – Class A	500	500	10	$\mathbf{0.027*p_t^{0.65}}$
Medium pressure – Class B	1000	750	20	$\mathbf{0.009*p_t^{0.65}}$
High pressure – Class C	2000	750	40	$\mathbf{0.003*p_t^{0.65}}$

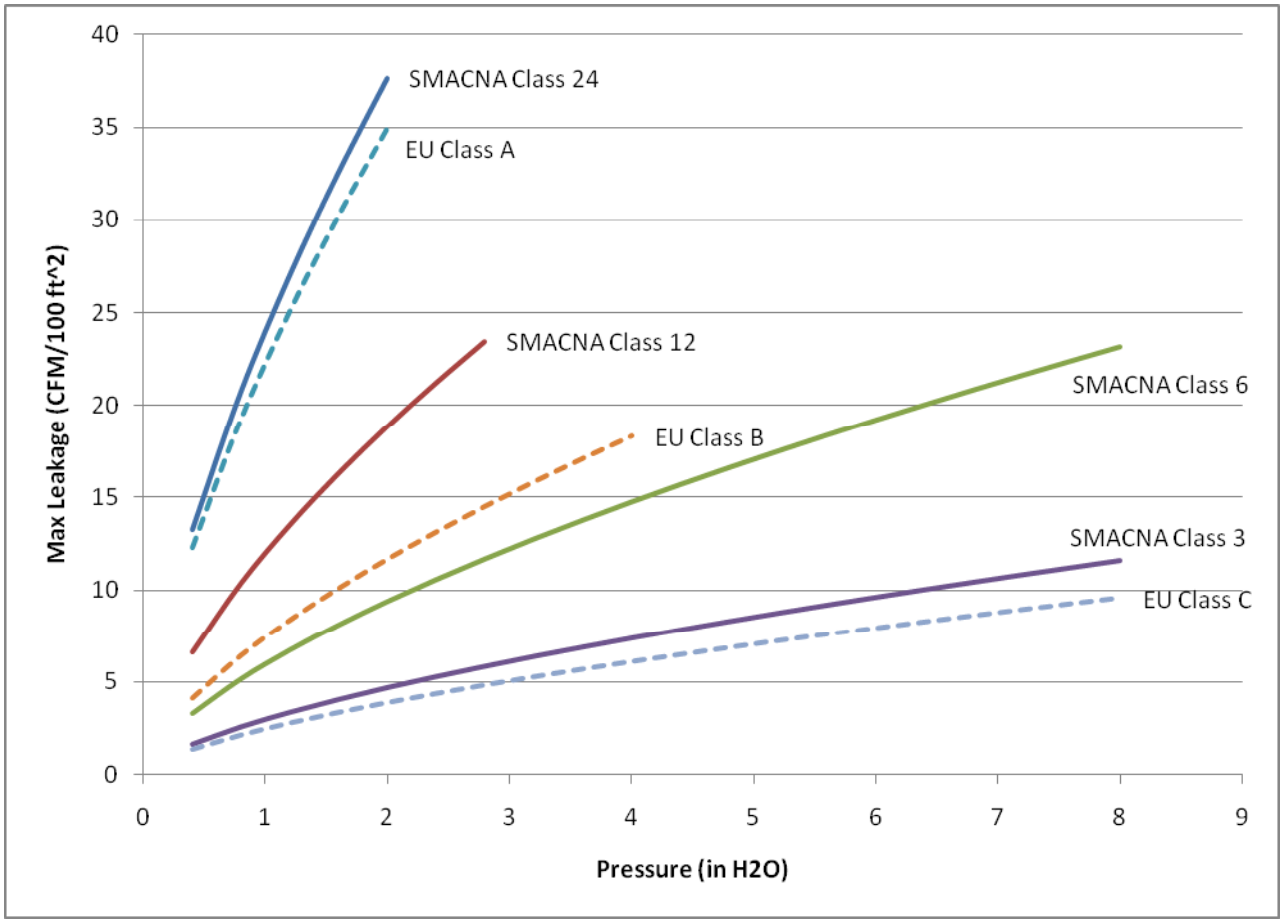
- P_t = test pressure

European Duct Leakage Requirements - Rectangular Ducts

Air Tightness Class	Static Pressure Limit (p_s) Pa				Air Leakage Limit l/s/m^2
	Negative	Positive at pressure class			
		1	2	3	
Low pressure – Class A	500	400	NA	NA	**$0.027*p_t^{0.65}$**
Medium pressure – Class B	750	400	1000	2000	**$0.009*p_t^{0.65}$**
High pressure – Class C	750	400	1000	2000	**$0.003*p_t^{0.65}$**

- P_t = test pressure

Comparison of SMACNA & EU Leakage Requirements



Comparison

	EU Standards	SMACNA Standard
Standard / Actual Conversions	Required	Suggested if: • Air Temp <40°F or >100°F • Elevation >1500 feet • Duct static <-20 in H_2O or >+20 in H_2O

Comparison

	EU Standards	SMACNA Standard

Report Requirements	Specified in Standards
	• Site details
	  • Date
	  • Location
	  • Test equipment
	  • Personnel & witnesses
	  • Ductwork installer & manufacturer
	  • Duct design operating pressure
	  • Required Air Tightness Class
		Defers to project specifications. Suggests:
		• Site Details
		  • Date
		  • Location
		  • Personnel & witnesses
		  • Duct section tested

Comparison

	EU Standards	SMACNA Standard

Report Requirements	Specified in Standards
	• Measurements
	  • Duct surface area
	  • Test pressure
	  • Leakage rate
	  • Pressurizing time
	• Calculated
	  • Leakage factor
	  • Air Leakage Limit
	  • Pass/fail result
		Defers to project specifications. Suggests:
		• Measurements
		  • Duct surface area
		  • Test pressure
		  • Leakage rate
		• Calculated
		  • Max Air Leakage allowed
		  • Pass/fail result