ENERGY AND COMFORT

Ventilation Testing

Positive and Negative Duct Accreditation (PANDA) System

Model PAN200 Series

Operation and Service Manual

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b. Pumps are warranted for hours of operation as set forth in product or operator's manuals;
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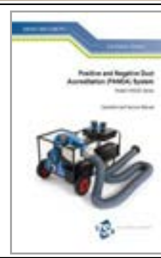
Unpacking and Parts Identification

Carefully unpack the PANDA system and instrument cases from the shipping container. Check the individual parts against the list of components below. If anything is missing or damaged, notify TSI immediately.

The PANDA system consists of the following:

Qty	Description	Part Number	Reference Picture
1	Low flow nozzle	6002598	
1	Primary duct adapter spigot plus rubber bung (to fit to test duct)	6002638	
1	Cam lock primary spigot (to connect flexi-duct to PANDA)	6002607	
2	Ø4-in. (100-mm) adjustable over lock straps	6002683	
1	13-ft (4-m) long Ø4-in. (100-mm) plastic flexible duct	6002667	
2	20-in. (500-mm) silicone tubes (red)	AFL9020004	

Qty	Description	Part Number	Reference Picture
2	20-in. (500-mm) silicone tubes (blue)	AFL9020005	
1	16-ft (5-m) silicone tube (blue)	AFL9020005	
1	Smoke cap holder assembly	AFL71549801	
1	Smoke pellets	AFL9004167	
1	K-type thermocouple probe	AFL82859201	
3	Instrument adapter	AFL82859401	
1	Operation and User's manual	6005007	

The following two instruments should be used in conjunction with the PANDA unit:

9565-P Multi-function Instrument		Refer to Operation and Service Manual (TSI P/N 6004851) supplied with the instrument for additional parts supplied as standard.
5825 Micromanometer		Refer to Operation and Service Manual (TSI P/N 1980568) supplied with the instrument for additional parts supplied as standard.

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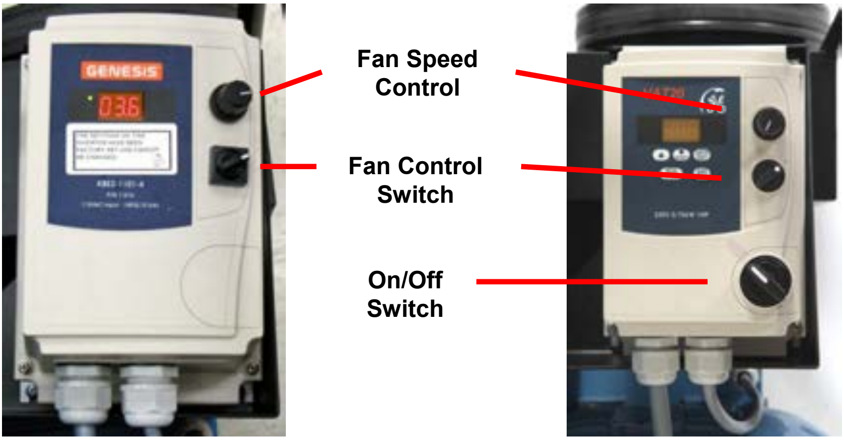
Preparing PAN200 System for Air Duct Leak Testing

The following procedure should be followed carefully so that safe and accurate leakage testing can be achieved:

> Successfully completing a duct leakage test requires certain information be compiled prior to starting the test. Refer to Appendix B for a discussion of standards relating to duct leakage testing. The list below indicates the information required:
>
> - Type of leakage test to be performed (Positive or negative).
> - Leakage standard to be followed.
> - Air tightness/leakage class to be achieved
> - Amount of ductwork to be tested, such as the complete system or a statistical sample.

1. Select the section of the ductwork to be tested.
2. Calculate the surface area of the ductwork of the section to be tested.
3. Temporarily seal the all openings of the ductwork except one, which will be connected to the PAN200 duct leakage tester.
4. Position the PAN200 unit as close to the remaining opening in the ductwork as possible to minimize the flexible tubing needed. Minimize bends in the flexible tubing to reduce the pressure loss, giving the best performance.
5. Make sure the Fan Control Switch on the Fan Speed Controller is in the **OFF** position and the multi-turn Fan Speed Control potentiometer is fully turned counter-clockwise using the pictures of the VFD in Figure 1 as a reference. Plug the cord into the PANDA unit as shown in Figure 2 and Figure 3. Then connect the other end of the cord to a suitable electrical supply.

CAUTION:	Remove the power cord from the PANDA duct leakage tester before tilting it to the vertical position to avoid damaging the cord.



110 V **230 V**

Figure 1. 110V and 230V Fan Speed Controllers

Note:	The control pad on the Fan Speed Controller has been disabled.

Figure 2. Receptacle for Power Cord

Figure 3. Connected Power Cord

6. Fit the primary duct adapter spigot (black sheet metal with rubber bung) to one end of the 4-in. (100-mm) diameter flexi-tube. Make an air-tight seal using one of the over lock straps and lever-locking cam provided as shown in Figure 4. Adjust the fit of the over lock strap with a screwdriver.

Figure 4. Flex Ductwork Connected to Primary Adapter Spigot. Bung not shown.

7. Securely attach the black primary duct adapter spigot/flexi-tube assembly to the opening on the ductwork to be pressure tested.

8. If the static pressure tap on the black Primary Duct Adapter is open to the duct, connect the 16-ft (5-m) long blue silicone tube to it as shown in Figure 5.

   If the static pressure tap on the black Primary Duct Adapter is not open to the duct, drill a 4-mm hole in the duct and insert about 6 inches (10 mm) of the silicone tube into the duct. Seal around the hole with putty.

Figure 5. Connecting Pressure Tubing to Tap on Primary Duct Adapter. Bung not shown.

9. Connect the other end of the 4-in. (100-mm) flexi-tube to the cam lock connector (grey cast aluminum without nozzle). Make an airtight seal using the other over lock strap and lever-locking cam provided. Adjust the fit of the over lock strap with a screwdriver.

10. Determine if you are going to perform a high- or low-flow testing and positive or negative testing. Set-up the duct leakage tester by:

a. For positive pressure, high-flow testing, remove the low flow nozzle if it is installed. Then, connect the grey cast-aluminum cam lock connector to the outlet side of the blower per Figure 6. Close both cam lock arms at the same time to ensure proper fit.

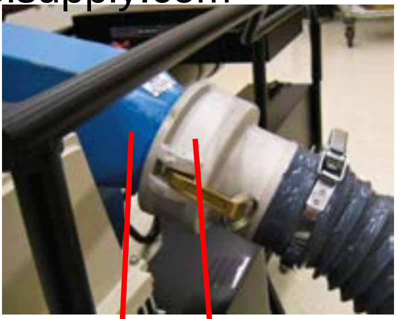


Figure 6. Positive Pressure, High-Flow Set-Up

Connect the free end of the 16-ft (5-m) silicone tube to the pressure tap marked **DUCT PRESSURE P3 (+)** on the black square box.

Finally, verify that the **FLOW GRID MODE** pressure taps on the inlet tubes are connected to the **FLOW GRID** pressure taps, i.e., **P1 (+)** to **P1 (+)** and **P2 (-)** to **P2 (-)**.

b. For positive pressure, low-flow testing, add the low-flow nozzle to the blower inlet if it is not installed per Figure 7. Then, connect the grey cast-aluminum cam lock connector to the outlet side of the blower per Figure 6. Close both cam lock arms at the same time to ensure proper fit.

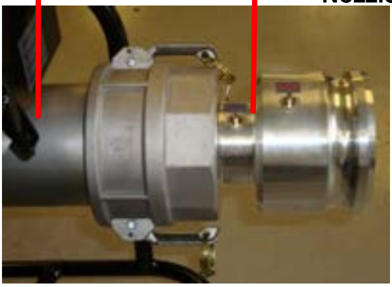


Figure 7. Positive Pressure, Low-Flow Set-Up

Connect the free end of the 16-ft (5-m) silicone tube to the pressure tap marked **DUCT PRESSURE P3 (+)** on the black square box.

c. For negative pressure, high-flow testing, remove the low flow nozzle if it is installed. Then, connect the grey cast aluminum cam lock connector to the inlet side of the blower per Figure 8. Close both cam lock arms at the same time to ensure proper fit.

Figure 8. Negative Pressure, High-Flow Set-Up

Connect the free end of the 16-ft (5-m) silicone tube to pressure tap marked **DUCT PRESSURE P4 (-)** on the black square box.

Finally, verify that the **FLOW GRID MODE** pressure taps on the inlet tubes are connected to the **FLOW GRID** pressure taps, i.e., **P1 (+)** to **P1 (+)** and **P2 (-)** to **P2 (-)**.

d. For negative pressure, low-flow testing, add the low-flow nozzle to the blower inlet if it is not installed. Then, connect the grey cast aluminum cam lock connector to the low-flow nozzle per Figure 9. Close both cam lock arms at the same time to ensure proper fit.

Figure 9. Negative Pressure, Low-Flow Set-Up

Connect the free end of the 16-ft (5-m) silicone tube to pressure tap marked **DUCT PRESSURE P4 (-)** on the black square box.

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Performing a Duct Leakage Test

The PAN200 duct leakage test system includes a Model 5825 Micromanometer and a Model 9565-P Ventilation Meter. During duct leakage testing, the Model 5825 Micromanometer measures the duct static pressure while the Model 9565-P Ventilation Meter measures the airflow rate.

Refer to the Operation and Service Manuals for the Model 5825 Micromanometer and the Model 9565-P Ventilation Meter to use these instruments in other applications. If you do not have the manuals, download them from TSI's website www.tsi.com.

Measuring Duct Static Pressure

1. Turn ON the Model 5825.
2. Zero the Model 5825 pressure sensor with both ports open to the atmosphere.
3. Connect the (+) port on the Model 5825 to **P3 (+)** to measure the duct static pressure (see Figure 6).
4. Leave the (-) port on the Model 5825 open to the atmosphere.

Note: *Refer to the Model 5825 Operation and Service Manual for instructions on using data logging to automatically record the duct static pressure.*

Measuring Duct Leakage Flow

1. Turn ON Model 9565-P.
2. Zero the Model 9565-P pressure sensor with both ports open to the atmosphere.
3. Connect the Model 9565-P to the PAN200 by connecting the (+) and (-) ports on the Model 9565-P to the **P1 (+)** and **P2 (+)** ports located inside the black box of the PAN200as shown in Figure 10.

Figure 10. Connecting Instruments to PANDA Tester in High Flow Mode

4. Connect the thermocouple to the Model 9565-P.
5. Insert the thermocouple probe into the blower inlet through the hole marked **TC1** as shown in Figure 11.

Figure 11. Thermocouple Insertion Hole

Turning on the PAN200 Duct Leakage Tester

1. Switch the PANDA unit on.
   a. For 230V models position the Mains Power switch of the inverter to the **ON** position to power the Inverter speed controller. The Fan motor is not energized.
   b. 110V models do ***not*** include a separate power switch. The PANDA unit is turned on when the power cord is plugged in.
2. Position the Fan Control switch to the **RUN** position to energize the fan.
3. Increase the fan to the desired speed by turning the Fan Speed Controller clockwise. To decrease the fan speed, turn the Fan Speed controller counter-clockwise.

Using Leakage Test Application in the Model 9565-P

CAUTION:	The Model 5825 and Model 9565-P meters must be zeroed before entering the Leakage Test Application.

1. Press the **MENU** key to access the menu system on the Model 9565-P.
2. Use the ▲▼ keys to highlight the Applications item.
3. Press the ↵ **(ENTER)** key to access the Applications menu.

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

4. Select **Leakage Test** and press ↵ key.

APPLICATIONS
Draft Rate
Heatflow
Turbulence
% Outside Air
Leakage Test

5. Select either the **EN Standard** or **SMACNA** leakage test.

LEAKAGE TEST
EN Standard
SMACNA

Instrument Operation if EN Standard Test Protocol is Selected

LEAKAGE TEST
Surface Area
Static Pressure
Flow Device
Tightness Class
Test Length
Run Test

1. Enter key parameters:
   a. Surface Area of ductwork section to be tested.
   b. Static Pressure of test, as measured by Model 5825 micromanometer.
   c. Flow Device as Nozzle or Flow Grid.
   d. Leakage class as A, B, C, or D. Note that tests with negative pressures must be selected as negative tests, as indicated by -.
   e. Test Length, or duration of leakage test, usually 5 minutes.

LEAKAGE TEST	
Leakage Factor	x.xx
Leak Limit	x.xx
Leak Rate	x.xx
Status	OK
Flow Device	Flow Grid
Baro Pressure	20.20
Temperature	20°C
Time	9:55
Standard	TestXXX Sample 0
(Sample Saved	1)

2. Increase the blower speed until the desired static pressure is achieved.
3. When the static pressure has stabilized, select **Run Test** and press ↵.
4. The display will show the readings on the right. Leakage Factor and Leak Rate will update in real time, while other parameters will remain constant.

   If the Leakage Factor and Leak Rate are sufficiently stable, press the **START** soft key or the ↵ key to begin the leak test. Pressing the **ESC** key will exit back to the previous screen.
5. After the leak test is complete, the Model 9565-P will prompt you to press the **SAVE** or **PRINT** soft key. You can also press the **ESC** key here to back out to the previous screen without saving the data.

After completing leakage testing for a section of duct, you can move on to the next section.

Instrument Operation if SMACNA Test Protocol is Selected

LEAKAGE TEST
Surface Area
Static Pressure
Flow Device
Leakage Class
Test Length
Run Test

1. Enter key parameters:
   a. Surface Area of ductwork section to be tested.
   b. Static Pressure of test, as measured by Model 5825 micromanometer.
   c. Flow Device as Nozzle or Flow Grid.
   d. Leakage class as a number from 1 to 48. Typical values are 3, 6, 12, 24, or 48.
   e. Test Length, or duration of leakage test.
2. Increase the blower speed until the desired static pressure is achieved.
3. When the static pressure has stabilized, select **Run Test** and press ↵.

LEAKAGE TEST	
Leakage Factor	x.xx
Leak Limit	x.xx
Leak Rate	x.xx
Status	OK
Flow Device	Flow Grid
Baro Pressure	20.20
Temperature	20°C
Time	9:55
Standard	TestXXX
	Sample
	0
(Sample Saved 1)	
Stop(Save) Print	

4. The display will show the readings on the right. Leakage Factor and Leak Rate will update in real time, while other parameters will remain constant.

   If the Leak Factor and Leak Rate are sufficiently stable, press the **START** soft key or the ↵ key to begin the leak test. Pressing the **ESC** key will exit back to the previous screen.
5. After the leak test is complete, the Model 9565-P will prompt you to press the **SAVE** or **PRINT** soft key. You can also press the **ESC** key here to back out to the previous screen without saving the data.

After completing leakage testing for a section of duct, you can move on to the next section.

Troubleshooting Guide

Symptom	Recommended Action
Fan motor will not run.	• Check the power connection. • Circuit Breaker may have tripped.
Static pressure reading (on 5825) is zero.	• Check the connections.
Static pressure reading (on 5825) is too low. Required static pressure cannot be achieved with motor speed control settings at the maximum.	• Leakage rate is too high. Check for leaks using soap bubbles or smoke pallets. Alternatively, test a smaller section of the ductwork.
Leak Flow (on 9565-P) shows flashing XXX.XX.	• Check the pressure tube connections to the 9565-P meter. • Leak flow is too low. Use low flow nozzle adapter.

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Specifications

Pressure Measurement (5825)

Range..................................	± 3,735 Pa (± 15 in. W.G.)
Resolution	0.1 Pa (0.001 in. W.G.)
Accuracy	1% of reading ± 1 Pa (± 0.005 in. W.G.)
Actual duct static range.......	± 2,500 Pa (± 10 in. W.G.) at Zero Flow

Volume Flow Measurement (9565-P)

Wilson radial flow grid	High leakage range: 10 to 200 l/s (36 to $720\ m^3$/hr, 21 to 424 cfm)
15 mm conical inlet nozzle adapter	Low leakage range: 1 to 13 l/s (3.6 to $46.9\ m^3$/hr, 2 to 27.5 cfm)
Resolution	0.01 l/s ($0.01\ m^3$/hr, 0.01 cfm)
Accuracy	± 2.5% of reading ± 0.01 l/s (± $0.04\ m^3$/hr, ± 0.02 cfm)

Temperature Measurement (9565-P)

K Type thermocouple probe	To EN60584 (IEC 584)

Barometric Pressure Measurement (9565-P)

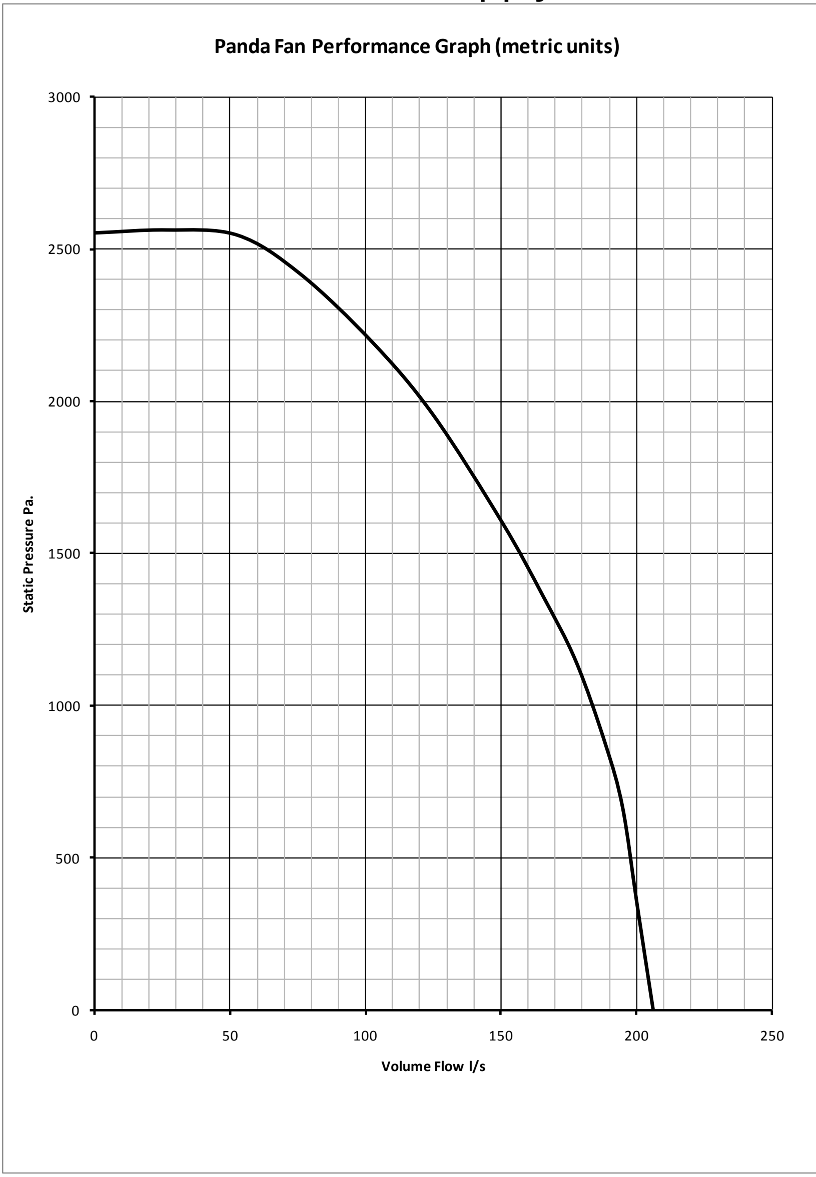
Range..................................	690 to 1,241 hPa (517.5 to 930.87 mm Hg, 20.36 to 36.648 in. Hg)
Accuracy	± 2% of reading

Power Requirements

Model PAN221*	220 to 240 V, 1 Phase, 50/60 Hz, 10A
Model PAN221-110*	110 to 120 V, 1 Phase, 50/60 Hz, 16A
Weight	71 kg (157 lbs.)
Dimensions (L x W x H)	1,130 mm x 660 mm x 510 mm (44.5 in. x 26 in. x 20 in.)
9565-P and 5825	See specification sheets for details on individual instruments

* Model: instruments included
** Model: instruments NOT included

(Specifications subject to change without notice.)



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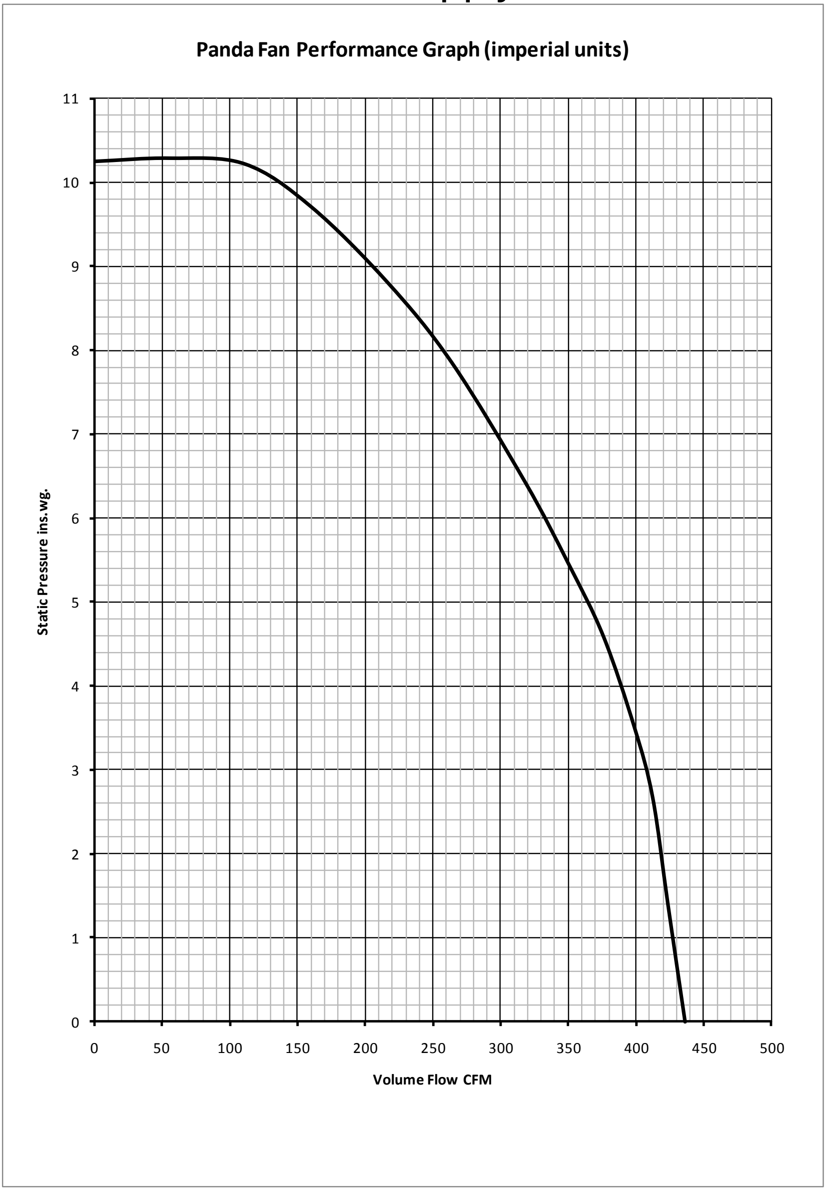
Panda Fan Performance Graph (imperial units)
Static Pressure ins.wg.
11
10
9
8
7
6
5
4
3
2
1
0
0
50
100
150
200
250
300
350
400
450
500
Volume Flow CFM

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Leakage Testing Standards Highlights

Different standards are used throughout the world to specify duct air tightness and leakage requirements. The PAN200 duct leakage test system has a duct leakage application to automatically compare the actual leakage flow with the maximum allowed leakage flow for EN and SMACNA standards. Field technicians can also use the duct leakage application to determine actual leakage flow and manually compare it to maximum leakage from another standard. The PAN200duct leakage test system cannot determine the appropriate leakage classification for a given duct.

Standards Supported

Standard	US- or EU-Based	Description
BS EN 12237:2003	EU	Ventilation for buildings—Ductwork—Strength and leakage of circular sheet metal ducts.
BS EN 1507:2006	EU	Ventilation for buildings—Sheet metal air ducts with rectangular section—Requirements for strength and leakage.
DW/143	EU	HVAC—A practical guide to Ductwork leakage testing.
Eurovent 2/2	EU	Air leakage rate in sheet metal air distribution systems.
SMACNA HVAC Air Duct Leakage Test manual, First edition, 1985	US	Duct construction leakage classification, expected leakage rates for sealed and unsealed ductwork, duct leakage test procedures, recommendations on use of leakage testing, types of test apparatus and test setup and sample leakage analysis.

TSI has made every effort to accurately reflect the standards referenced. Please refer to the actual standards for more detailed information and to make the best interpretation of each statement.

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The scope of the standards listed above includes many items other than duct leakage. This summary, however, is limited to duct leakage testing.

EU Standards

Ductwork classification and maximum air leakage. Note that EN1507, EN12237 Eurovent 2/2 and DW/143 all have the same formula to determine f_{max}, the Air Leakage Limit, although DW/143 uses units of $l/s/m^2$ whereas others use $m^3/s/m^2$.

- EN 1507 (rectangular ductwork)

Air Tightness Class	Air Leakage Limit (f_{max}) $m^3/s/m^2$	Static Pressure Limit (p_s) Pa			
		Negative	Positive at pressure class 1	2	3
A	$\frac{0.027 * p_t^{0.65}}{1000}$	200	400		
B	$\frac{0.009 * p_t^{0.65}}{1000}$	500	400	1000	2000
C	$\frac{0.003 * p_t^{0.65}}{1000}$	750	400	1000	2000
D*	$\frac{0.001 * p_t^{0.65}}{1000}$	750	400	1000	2000

* Class D ductwork is only for special apparatus

- EN12237 (circular ductwork)

Air Tightness Class	Air leakage limit (f_{max}) $m^{3*}/s/m^2$	Static Pressure Limit (p_s) Pa	
		Negative	Positive
A	$\frac{0.027 * p_t^{0.65}}{1000}$	500	500
B	$\frac{0.009 * p_t^{0.65}}{1000}$	750	1000
C	$\frac{0.003 * p_t^{0.65}}{1000}$	750	2000
D*	$\frac{0.001 * p_t^{0.65}}{1000}$	750	2000

* Class D ductwork is only for special apparatus

- Eurovent 2/2 Air Tightness For Installed Duct Testing:

Air Tightness Class	Air leakage limit (f_{max}) $m^3/s/m^2$
A	$\frac{0.027 * p_t^{0.65}}{1000}$
B	$\frac{0.009 * p_t^{0.65}}{1000}$
C	$\frac{0.003 * p_t^{0.65}}{1000}$

- DW/143: A Practical Guide to Ductwork Leakage Testing

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

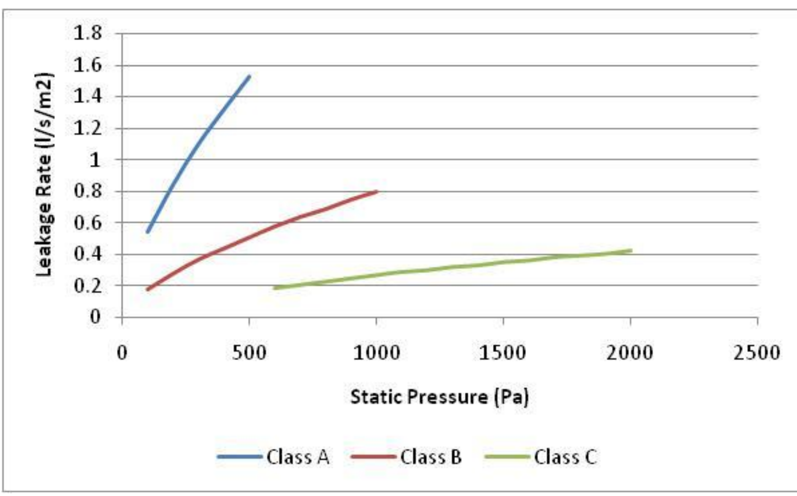

Figure 12. Allowable Air Leakage Rates from DW/143

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- The measured leakage flow rates shall be corrected if the temperature and/or barometric pressure are different from standard conditions (+20ºC and 101 325 Pa) as follows:

$$q_v = q_{measured} \cdot \frac{293}{273 + t} \cdot \frac{p}{101325}$$

where:

q_v=corrected flow leakage rate
$q_{measured}$ = measured flow leakage rate
t = measured temperature (ºC)
p = measured barometric pressure (Pa)

- The test report shall give the following general information of the test performed:
  - Date and place
  - Test personnel and witness
  - Test equipment, including pressuring means and measuring instruments
  - Air temperature and barometric pressure during the test
  - Building and project reference
  - Design of installed ductwork including dimensions, thickness of materials, types of stiffening, length, type of duct/tubes and fittings, assembly method and distance of hangers/supports
  - Required air tightness class and design operating pressure of the installed ductwork
  - Installer of ductwork
  - Manufacturer of the ductwork
  - Measured values of:
    1. Ductwork surface area (A)
    2. Total joint length (L)
    3. Test pressure (p_{test})
    4. Leakage flow rate (q_v) corrected for temperature and barometric pressure
    5. Pressurizing time

- Calculated values of
  1. Leakage factor (f)
  2. Air leakage limit (f_{max}) according to the formulas given in table above at the measured test pressure (p_{test})
- Air tightness class achieved

- For tests including several test pressures it is recommended to plot the leakage factors as a function of test pressure in a diagram together with the air leakage limit curve.

US Standards

Ductwork classification and maximum air leakage

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			
Rectangular Metal	24	12	6
Round Metal	12	6	3

Maximum air leakage is then defined as
$F = C_L P^{0.65}$

where: F = Maximum air leakage (cfm/100 ft^2)
C_L = Leakage class
P = Pressure (inwg)

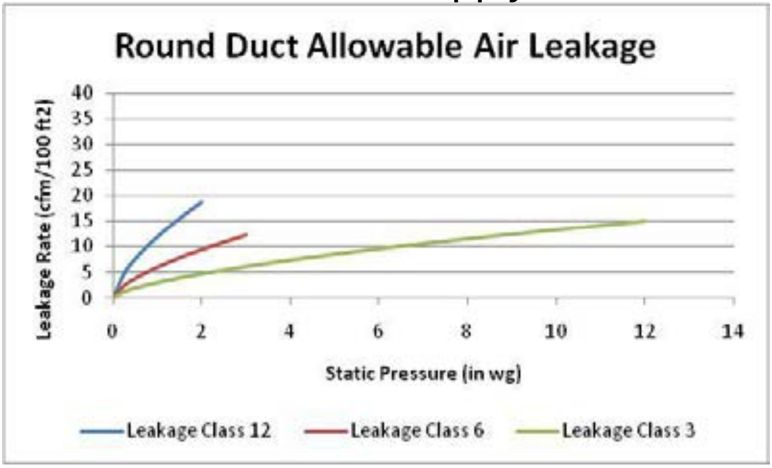

Figure 13. Allowable Air Duct Leakage from Round Ducts, per SMACNA Standard

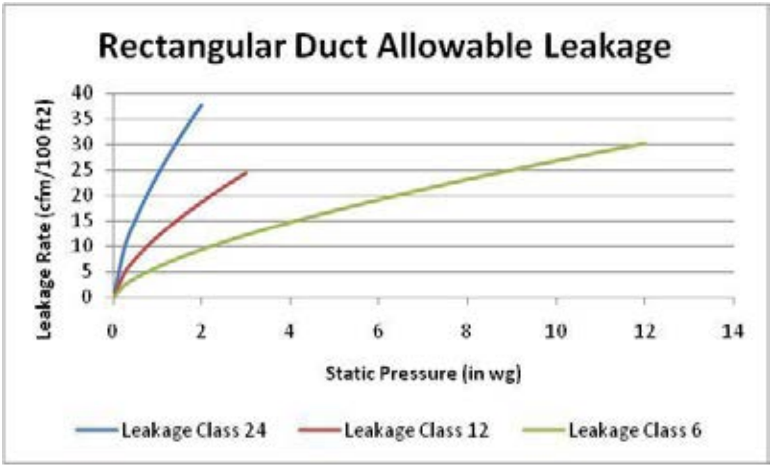

Figure 14. Allowable Air Duct Leakage from Rectangular Ducts, per SMACNA Standard

- The SMACNA standard does not generally require correcting leakage flow rates to standard conditions, unless:
  1. Air temperature <40ºF or >100 ºF
  2. Elevation <1500 ft above sea level
  3. Duct static pressure <-20 inwg or >+20 inwg

Should one of these conditions not be satisfied, then correcting the leakage to standard conditions may be done using one of these formulas:

1. ACFM=SCFM * (460+T)/530
   where T = actual dry bulb air temperature (ºF)
   moisture is negligible
   pressure between -20 and +20 inwg
2. ACFM = SCFM * 0.075/d
   where d = air density from psychrometric chart
3. ACFM=lb dry air/minute * humid volume (ft^3/lb dry air)

- The SMACNA standard does not specify the information to be reported, but instead defers to project documents. However, the SMACNA standard does include a sample test report that includes:
  - Test date and place
  - Test personnel and witness
  - Building and project reference
  - Duct section tested
  - Specified leakage class, test pressure and duct construction pressure class
  - Measurements of:
    - Ductwork surface area
    - Leakage flow and calculations required to determine leakage flow

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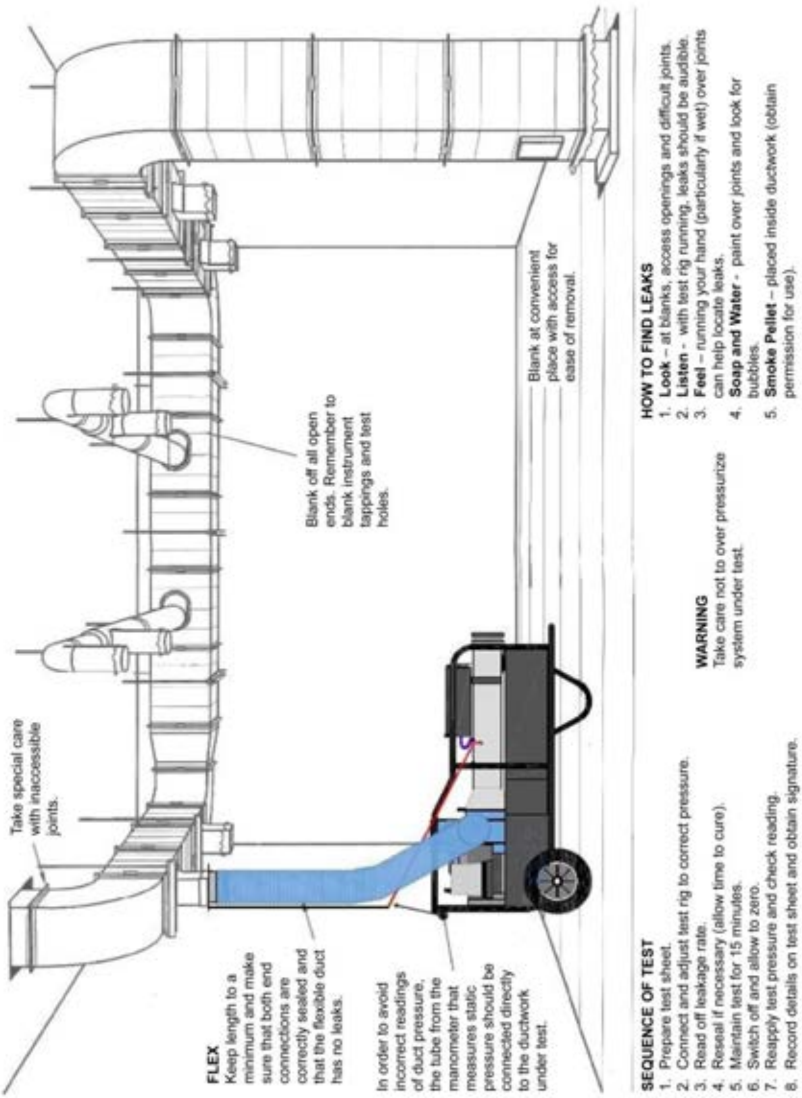
Appendix C

Typical Setup



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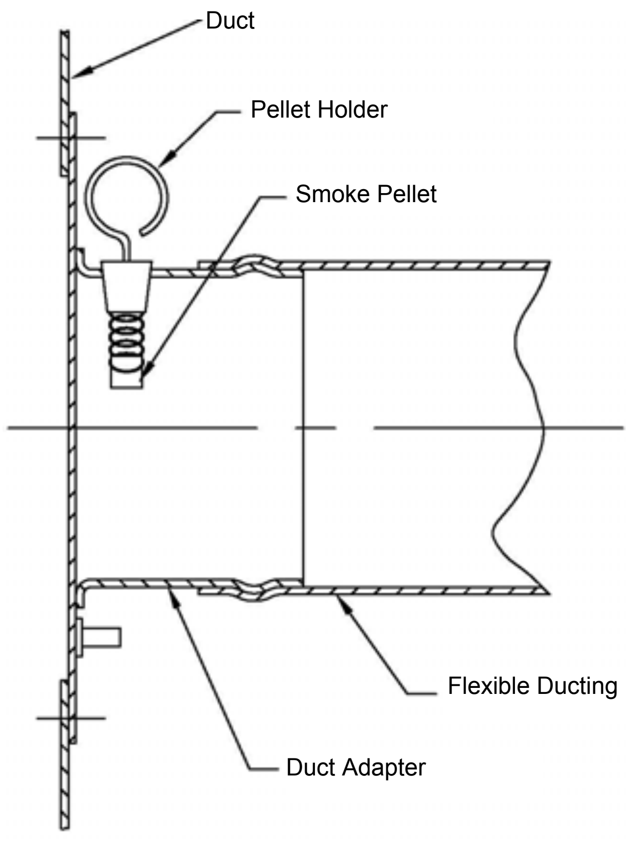
Procedure for Using Smoke Pellets in Leakage Testers

As shown in the sketch below, a rubber bung is fitted into the hole in the duct adapter which holds the wire coil.

When a smoke pellet is required to be used, remove the bung and fit a pellet into the wire coil as shown in the sketch.

Light the pellet and immediately plug into the hole in the duct adapter and proceed with the test.

The pellet should emit dense white smoke for up to a minute.



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